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Rhythm®

Intelligent Planning and Scheduling Systems

Rhythm Tutorial Manual

i2 Technologies

Rhythm® Intelligent Planning and Scheduling Systems Tutorial Manual

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On the Cover: i2 Technologies provides solutions for intelligent planning and scheduling. It simultaneously considers all constraints. The graphic shows a customer handling all the constraints simultaneously to obtain significant business results. The constraints are (counterclockwise): Due Date Planning (calendar), Throughput (drum encircled by arrow), Operating Expenses (dollar sign), Inventory (pallet with boxes), Lead Time (clock). Decisions are made using global rather than local criteria, although global information is filtered and combined with local information (Note the globe).

Written and edited by Steven Chaples with contributions from the development and consulting groups of i2 Technologies, Inc.

Cover Designer: Julie Arata

Rhythm® MPPS (Master Production Planner & Scheduler) Version 2_8

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Rhythm®

January 31, 1996

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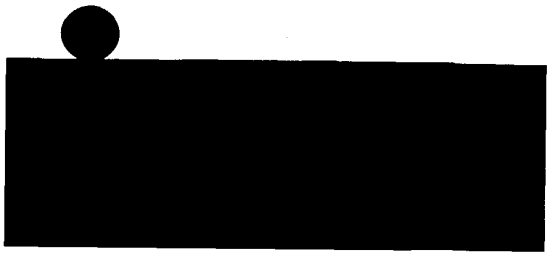
Rhythm Intelligent Planning and Scheduling Systems Tutorial Manual



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COMMENTS

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Section 1 Introduction

Scheduling is perhaps one of the most under utilized areas of opportunity for manufacturing competitiveness. Schedulers make decisions on a day-to-day basis that have major impact on the company's performance without, in most cases, the proper tools to provide visibility of the effect of their decisions on plant performance.

Rhythm® is a set of tools for Master Production Planning, Master Production Scheduling, Capacity Requirements Planning, and Dynamic Finite Scheduling. *Rhythm*® enables rapid what-if analysis and not only identifies problems but solves them or allows the user to interactively solve them. *Rhythm*® is fast. An important aspect of *Rhythm*® is the efficiency of its algorithms.

Rhythm® considers material and capacity constraints when developing the master production schedule by using *CAO*™, a technology which focuses on constraint anchored optimization. Constraints are dynamic and interdependent. They may change based on demand pattern or product mix. *CAO*™ optimizes the overall performance of the system by considering the trade-offs among conflicting objectives.

Rhythm® is an intelligent planning and scheduling system with the following properties:

- Decisions are based on the latest shop floor situation
- Incremental adjustments can be made without complete rescheduling
- High quality decisions are made in limited time using domain knowledge. Domain knowledge is used to focus the search in areas with a high possibility of yielding good solutions. Important decisions are separated from unimportant decisions (few scheduling systems have this capability). A typical domain characteristic is a known bottleneck.
- Decisions are made using global rather than just local criteria. Global information is filtered and combined with local information.
- Decisions are made at the appropriate temporal level. We perform planning for a longer horizon and scheduling only for a shorter horizon. If scheduling decisions are made too early, fluctuations will invalidate those decisions. The scheduling horizon depends on the benefits of predictive scheduling and the stability of the environment.
- Hard constraints are not violated. Soft constraints are relaxed in a manner which best achieves system goals
- The system and scheduling procedure is flexible and accommodates new goals, constraints, and operating conditions

1.1 Purpose

The purpose of *Rhythm*® training is to enable users to:

- Increase profitability by:

  - *Reducing* customer lead time
  - Increasing on-time performance
  - Reducing work in process
- Increase the service level offered to customers by having the capability to react quickly to change
- Synchronize production plans and schedules with the real-time rhythms of their customer demand
- Utilize manufacturing planning and scheduling algorithms to control capacity and inventory buffers

1.2 Objectives

After completing training, the user should:

- Understand the unique functional capabilities offered by *Rhythm*® MPPS, *Rhythm*® DS, and *Rhythm*® Interplant
- Understand how these functional capabilities relate to other manufacturing planning and control system applications

1.3 Overview of MPPS

Rhythm® MPPS is a planning tool that produces a Master Production Schedule. *Rhythm*® MPPS uses forward and backward scheduling around anchor resources to generate load profiles that minimize clogging and starvation and control the amount of setups such that due date and other performance objectives are achieved.

A unique feature of the *Rhythm*® scheduling architecture is its decomposition of scheduling into planning and detailed scheduling. *Rhythm*® MPPS first generates an infinite capacity plan for the given demand. This infinite capacity plan is the starting point for other modules, such as *CAO*™ and DS. *CAO*™ creates the finite capacity plan from the infinite capacity plan. Planning has the largest impact on manufacturing performance, but it does not consider minute-to-minute decisions or job by job sequencing, which is the domain of scheduling.

1.4 Overview of DS

Rhythm® DS is a short-term finite scheduling tool that considers all constraints and their interactions in complete detail. It is sensitive to the current shop status. It considers sequence-dependent setup times, batching constraints, transportation times, and other constraints. DS is used to create and execute the schedule according to plan.

1.5 Overview of Interplant

Rhythm® Interplant is designed for multi-plant manufacturing organizations. *Rhythm*® Interplant allows *Rhythm*® MPPS modules running at different sites to work together as a coordinated planning team.

1.6 Training Nomenclature

CAO	Constraint Anchored Optimization
DS	Dynamic Scheduling
MPPS	Master Production Planning & Scheduling

1.7 References

1. APICS Dictionary
2. *Rhythm*® Record Manual
3. *Rhythm*® Reference Manual
4. *Rhythm*® User's Manual
5. The UNIX Programming Environment
6. X Window System User's Guide

Section 2

Basic Guide

This section introduces you to *Rhythm*® MPPS. MPPS is an intelligent replacement for master production scheduling and capacity requirements planning modules in existing MRP II systems. It allows incremental scheduling and changes.

Rhythm® MPPS will allow you to synchronize manufacturing flow. It recognizes constraints in the system and develops solutions that consider capacity and material constraints simultaneously. All but the simplest manufacturing systems have multiple and moving constraints which requires that a software solution be implemented. If appropriate managerial and behavioral issues are addressed, the software can act as a cementing agent to formalize synchronous flow management.

2.1 Training Objectives

After completing this section, you should:

- Be able to interact with the graphical user interface (place windows, use the mouse, use menus, etc.)
- Be familiar with the menus of the *Rhythm*® *Main Window*
- Be able to interpret and respond to problems with the plan as identified in the *Problem Window*
- Be able to change the factory model
- Be able to customize views of data
- Be able to sort views of data
- Be able to search for particular data field values
- Be able to specify periods of unavailable capacity by using the *Resource Calendar*
- Be able to generate a quote for the delivery date of a particular quantity of a part
- Be able to view the factory model from various perspectives
- Know how to shutdown *Rhythm*® correctly

2.2 Terms

The following terms will be used during training to describe interactions with the interface:

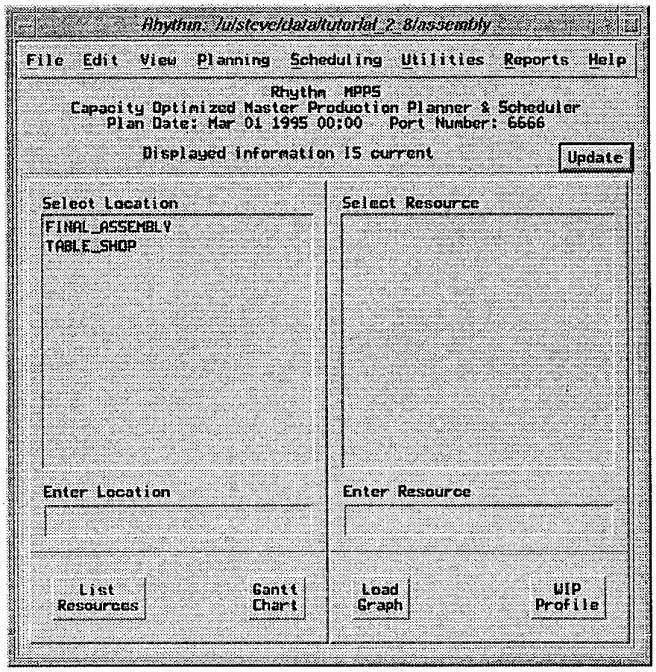
- *Click* - involves rapidly pressing and releasing the mouse button. In X Windows environments, the mouse typically has three buttons. If no specific button is referenced, the left button should be used.
- *Cursor* - refers to the indicator on the screen which shows where text will be placed when typed. The cursor should not be confused with the pointer. The cursor often is a flashing box. In an editor, the cursor often resembles a capital I.

- *Double Click* - involves rapidly pressing and releasing the mouse button twice. Normally, this is a shortcut that performs the same action as a click on an item plus a click on a button.
- *Drag* - involves holding down the left mouse button and moving the mouse pointer to a desired end position before releasing the button. One example is dragging the pointer across a word. This means, move the mouse to the beginning of the word, press and hold the left mouse button, move the mouse to the end of the word and let go of the left mouse button.
- *Pointer* - typically is the arrow on the screen which tracks mouse movement. The arrow may change to some other iconic shape (e.g., a watch face indicating that the system is busy).
- *Pop Up* - is a menu which may be obtained by pressing a mouse button in designated areas of the window. Normally, the left mouse button is pressed and the pointer is dragged to the desired selection in the pop up menu and released. Some pop up menus are obtained with the right mouse button. The use of the right mouse button will be indicated in the text when necessary.
- *Pressing* - involves pushing down and holding down the mouse button.In X Windows environments, the mouse typically has three buttons. If no specific mouse button is referenced, the left button should be used.
- *Pull Down* - is a menu at the top of a window. The left mouse button is clicked on the menu title causing the menu to appear, and the pointer is dragged to the desired selection and released.
- *Triple Click* - same as double click but the mouse button is clicked three times.
- *Type* - refers to a quick press and release of a keyboard key. Most keys repeat if held down.

2.3 Lesson 1 - Main Window

If you have not already done so, start *Rhythm*®. The *Main Window* should be visible. See FIGURE 1. The *Main Window* consists of two tiles. The left tile lists locations. The right tile lists resources at the selected location. Below each tile are buttons. Below the left tile, you can choose either *List Resources* or *Gantt Chart*. These buttons provide easy access to commonly used operations performed on locations. Below the right tile, you can choose either *Load Graph* or *WIP Profile*. These buttons provide easy access to commonly used operations performed on resources.

FIGURE 1 Main Window - Initial



Click on a location in the *Select Location* list.	The location will become highlighted (selected), and its name will appear in the *Enter Location* box (See FIGURE 2).
Click on the *List Resources* button.	The resources for the selected location are displayed in the *Select Resource* list (See FIGURE 3).
Double click on a location in the *Select Location* list.	The location will become highlighted (selected), and the resources for the selected location are displayed in the *Select Resource* list. This step is a shortcut for the previous two steps.

Click on a resource in the *Select Resource* list	The resource will become highlighted (selected), and its name will appear in the *Enter Resource* box (See FIGURE 4).

FIGURE 2 Main Window - Select Location

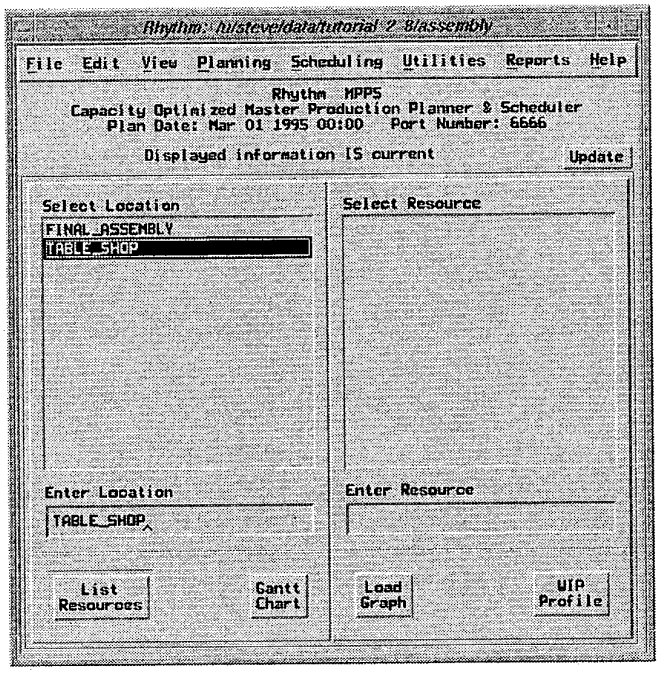


FIGURE 3 Main Window - List Resources

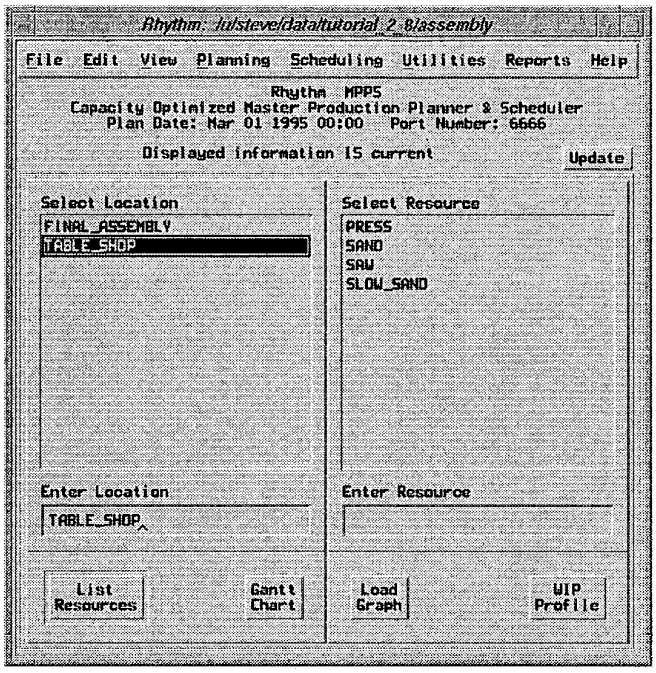
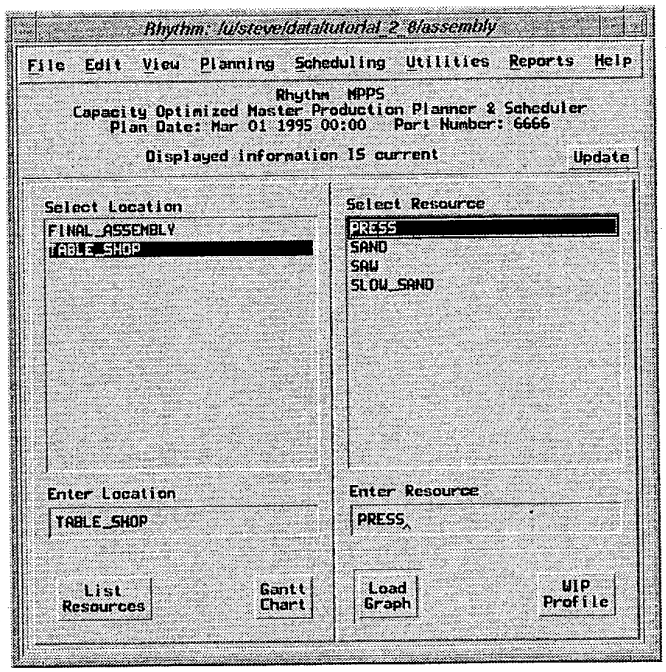


FIGURE 4 Main Window - Select Resource



2.4 Lesson 2 - Load Graph

If you have not already done so, start *Rhythm*® and follow the steps in the lesson for the *Main Window*.

Click on a resource in the *Select Resource* list.	The resource will become highlighted (selected), and its name will appear in the *Enter Resources* box (See FIGURE 4).
Click on the *Load Graph* button (or press and hold the right mouse button on a resource in the *Select Resource* list, then slide to the *Load Graph* option).	A *Load Graph* for the resource is opened (See FIGURE 5).
Position the *Load Graph* under the *Main Window*.	

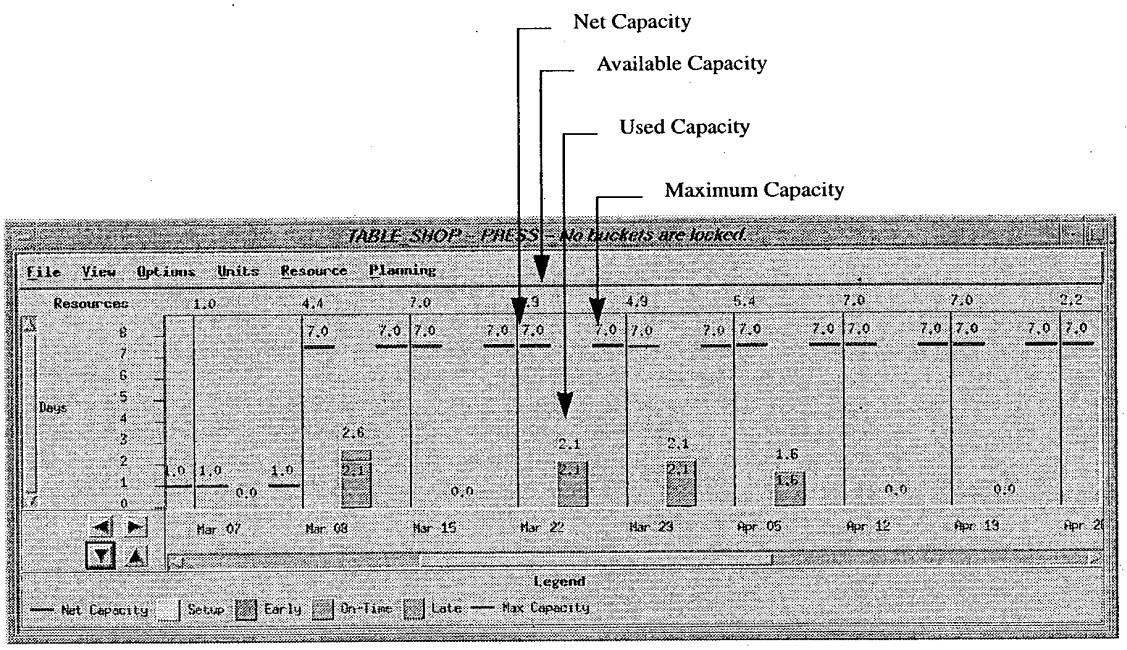
The vertical axis on the *Load Graph* represents days of work. The horizontal axis denotes calendar dates. Each group of dates is called a bucket. The bar in each bucket represents the amount of work to be performed on this resource during the specified time frame. The first bucket's date is the date supplied on the command line (or the current date by default) when starting the server.

Each bucket has four values shown: net capacity, maximum capacity, used capacity, and available capacity. Maximum capacity is typically the same as the bucket size. Net capacity is the maximum capacity minus items such as planned maintenance and less than 24-hour shifts. Used capacity is the amount of work assigned to this resource in this bucket. Available capacity is the net capacity minus the used capacity. Available capacity may be negative if the used capacity is larger than the net capacity. This indicates the resource is over utilized during this period.

The *Legend* appears in the lower left of the *Load Graph* being displayed. It defines each of the markings composing each bar:

- *Early* - number of orders that are completed before the due date
- *Late* - number of orders that are completed after the due date
- *Max Capacity* - same as the total theoretical capacity within the time bucket
- *Net Capacity* - theoretical capacity minus any time taken by Planned Maintenance, etc.
- *On-Time* - number of orders that are completed at the due date
- *Setup* - estimated setup time
- *Usage* - total time scheduled for a resource during a time bucket

FIGURE 5 Load Graph (By Lateness)



Press and hold the left mouse button on the scrollbar at the bottom of the *Load Graph*.

Drag the slider of the horizontal scrollbar to the right, then release the left mouse button.

This allows you to look at the load of the resource for dates in the future.

Click on the up arrow button.

This will rescale the vertical axis to show less days of capacity. Capacity values will begin to appear in the data bars, if they were not already visible, once a certain scale threshold is reached (See FIGURE 6).

Click on the down arrow button

This will rescale the vertical axis to show more days of capacity. Some capacity values may disappear once a certain scale threshold is reached

Click on the right arrow button.

This will rescale the horizontal axis to show fewer buckets. Capacity values will begin to appear, if they were not already visible, once a certain scale threshold is reached.

Click on the left arrow button.

This will rescale the horizontal axis to show more buckets (See FIGURE 7). Some capacity values may disappear once a certain scale threshold is reached.

Close the *Load Graph* by one of the following methods:
* select *Close* on the *File* pull down menu
* press and hold the left mouse button on the dash menu in the upper left corner and drag to the Close option, , or
* type <control>-c while the pointer is inside the window and the window is active.

FIGURE 6 Load Graph - Vertical Rescale

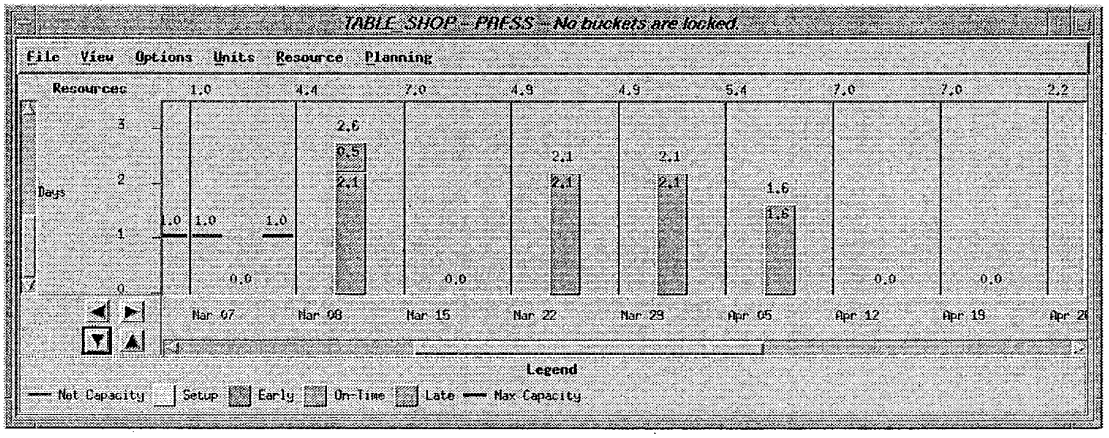
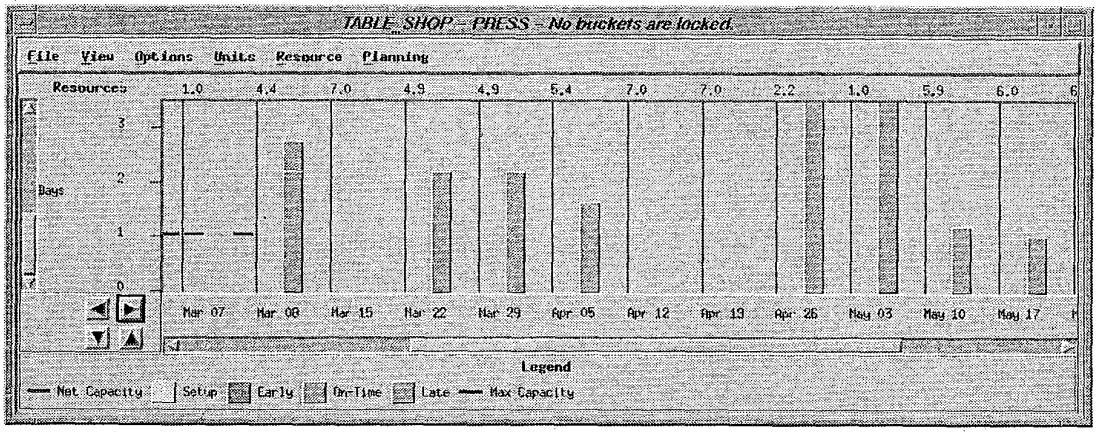


FIGURE 7 Load Graph - Horizontal Rescale



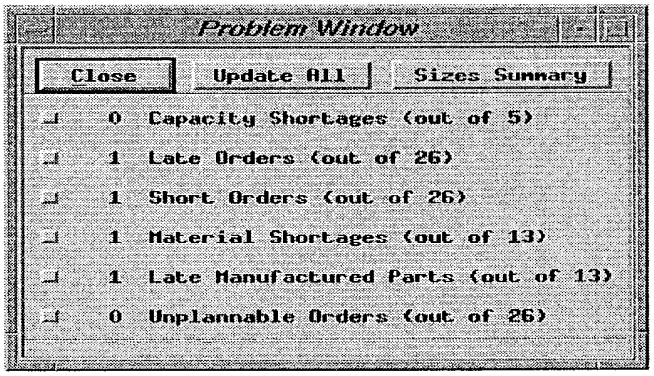
2.5 Lesson 3 - Problem Window

Now we will begin to examine problems with the plan as it exists before any of *Rhythm*®'s features are applied to it.

Select the *Problem Window* option from the *Utilities* menu of the *Main Window.* This opens the *Problem Window* (See FIGURE 8).

Position it to the right of the *Main Window.*

FIGURE 8 Problem Window



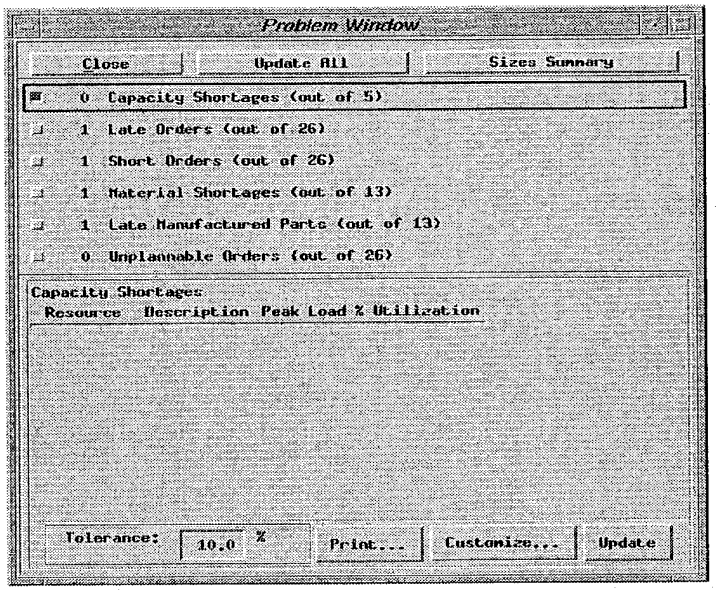
The *Problem Window* identifies the following types of problems:

- *Capacity Shortages*
- *Late Orders*
- *Short Orders*
- *Material Shortages*
- *WIP Shortages*

2.5.1 Responding to Capacity Shortages

Capacity Shortages identify resources which are over utilized in the plan. That is, they are planned to be used more than a user-defined percentage of time.

FIGURE 9 Capacity Shortages



View the list of *Capacity Shortages* by clicking on the appropriate option in the *Problem Window* (See FIGURE 9).

You may click anywhere on the line to activate an option. The button will now appear darkened (activated), and a pane for the selected option will appear, appended to the bottom of the *Problem Window*.

Note the *Tolerance* at the bottom of the window may be changed as desired. The tolerance is added to 100% to determine the threshold utilization. Negative values are allowed.

Click in front of the *Tolerance* value, type a negative (-), then click on the *Update* button.

For example, for -10%, this will allow you to view all resources with 90% utilization or greater (See FIGURE 10). Note the date of peak load for the first resource listed.

Click on the first resource listed.

This will open a *Load Graph* for the most over utilized resource.

Using the scroll bar, display the bucket where the peak load occurs (See FIGURE 11).

Note that the available capacity for this bucket is negative, indicating that more time is planned on this resource than is available.

Note the relationship between used capacity, available capacity, net capacity, and the peak utilization.

Examine the work being performed during this bucket by clicking the middle button while the pointer is inside the bucket.	This opens the *Tasks Planned* window for the resource during this bucket (See FIGURE 12).

FIGURE 10 OverUtilized Resources

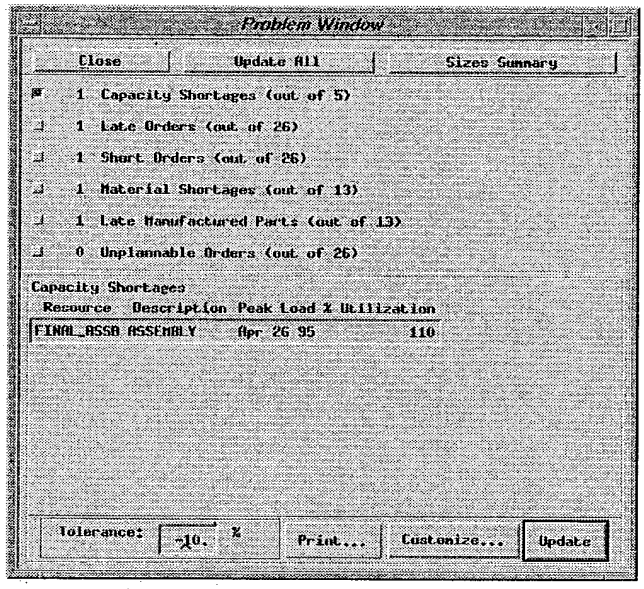


FIGURE 11 Load Graph - Peak Load

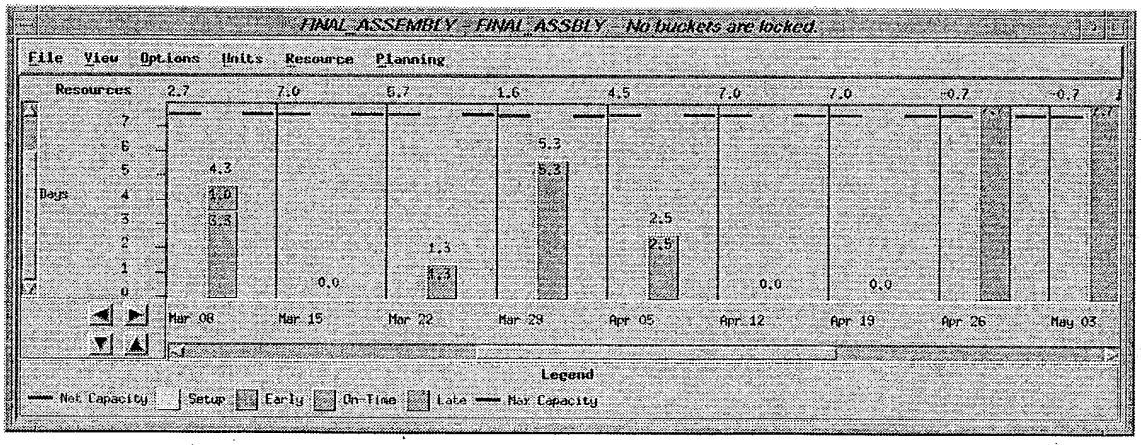
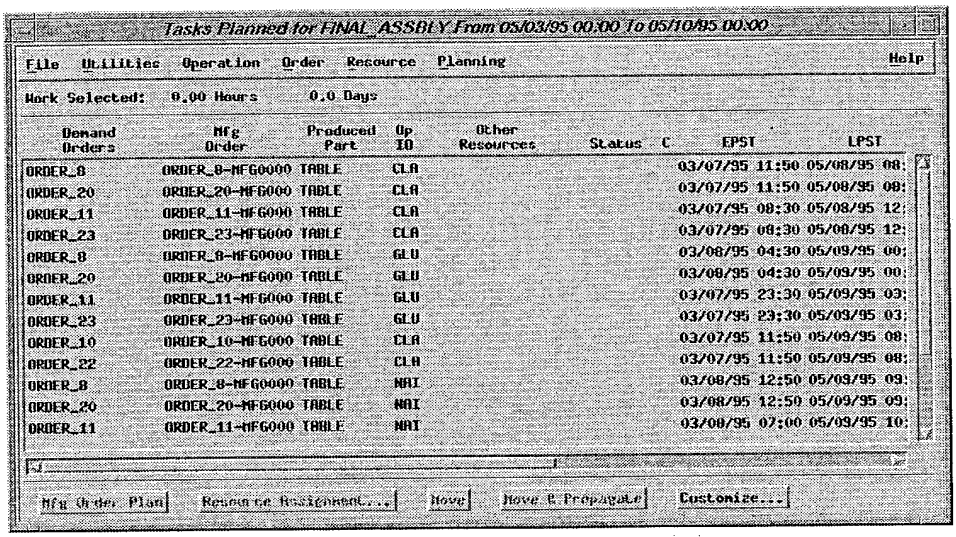


FIGURE 12 Tasks Planned



The *Tasks Planned* window (See FIGURE 12) displays information about the orders being worked upon this week. Three of the most interesting columns are labeled EPST (Earliest Possible Start Time), LPST (Latest Possible Start Time), and PST (Planned Start Time). EPST is determined by adding the cycle times of each step in the routings to the server start date while taking into consideration material constraints (infinite capacity, material-constrained, forward propagation). LPST is determined by infinite capacity, backward propagation from the due date. The PST is selected from within the time window delimited by EPST and LPST. If EPST is after LPST, the order will certainly be late and PST will be set equal to EPST.

From this window, we can:

- view the plan for a single order
- move work from one bucket to another bucket on the same resource
- off-load work to another resource
- automatically balance the work on this resource.

Examine the *Manufacturing Order Plan* for the first order by pressing and holding the right mouse button on the order (to access a pulldown menu) and then sliding to the *Manufacturing Order Plan* option.

This screen displays plan information for this order on all resources (See FIGURE 13).

Close the *Manufacturing Order Plan* window.

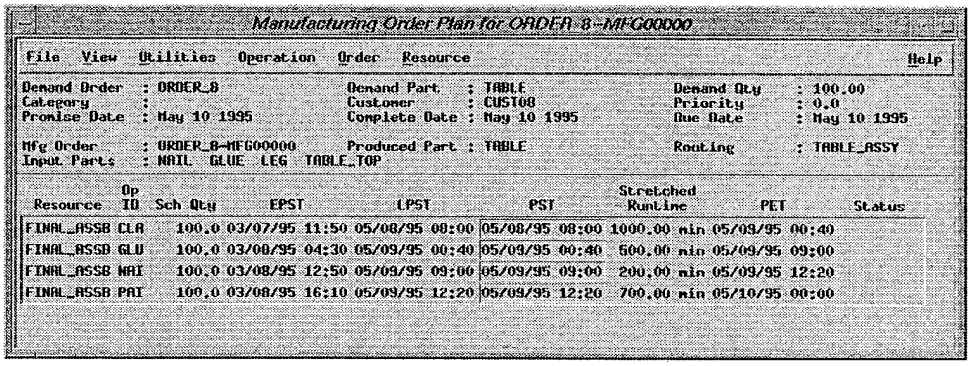
Close the *Load Graph*.

Note that the *Tasks Planned* window also closes since it was opened from the *Load Graph* window.

In the *Problem Window*, click on the box next to *Capacity Shortages*.

This will hide the list of *Capacity Shortages*.

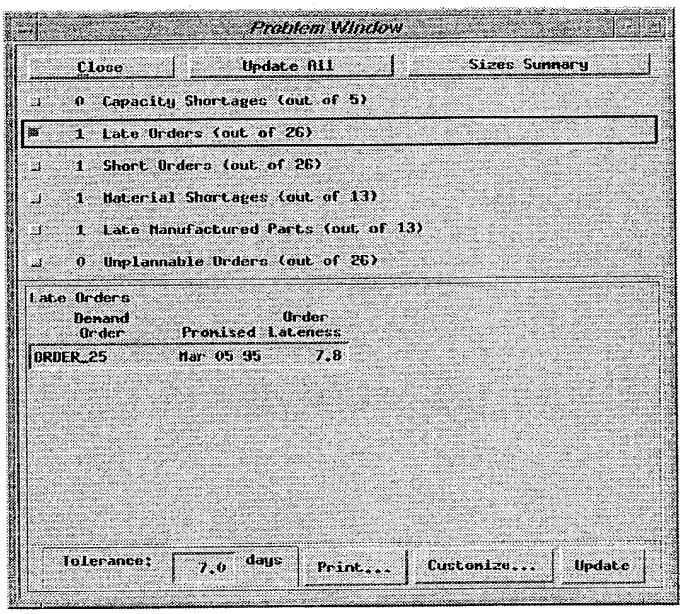
FIGURE 13 Manufacturing Order Plan



2.5.2 Responding to Late Orders

Late Orders identify orders which are planned to complete more than a user defined amount of time after their due date.

FIGURE 14 Late Orders



View the list of *Late Orders* by clicking on the appropriate option in the *Problem Window*.

You may click anywhere on the line to activate an option. The button will now appear darkened (activated), and a pane for the selected option will appear, appended to the bottom of the *Problem Window*.

Note the *Tolerance* at the bottom of the window may be changed as desired. Changing this value to zero will cause all *Late Orders* to be displayed.

Change the *Tolerance* value at the bottom of the window to zero and click the *Update* button (See FIGURE 14).

This value will cause all *Late Orders* to be displayed.

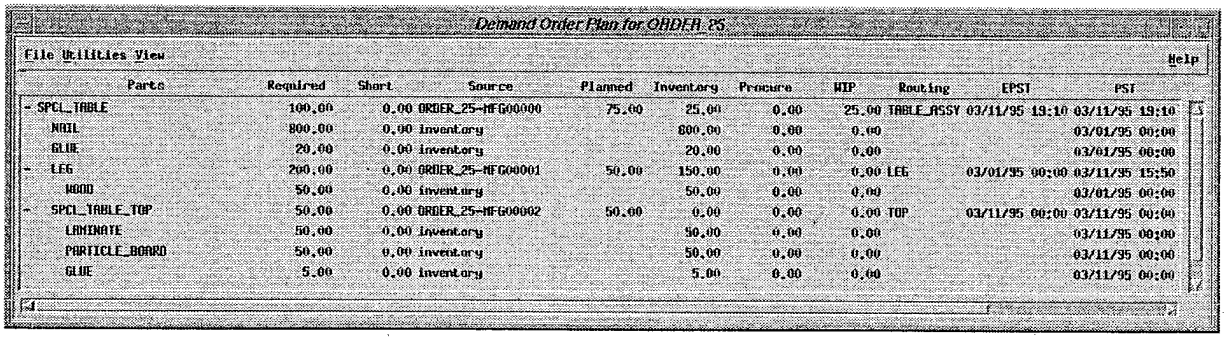
Click on the first order listed.

This will allow you to examine the order with the largest lateness.

The *Demand Order Plan* window will appear (See FIGURE 15). This window lists the order tree for the demand order, including the Planned Start Times (PSTs) and Planned Completion Times (PCTs).

Click on a component demand part.	The demand part will become highlighted (selected).
Select *Manufacturing Order Plan* from the *View* menu.	This will allow you to examine the *Manufacturing Order Plan* for the selected component demand part (See FIGURE 16).
Middle click on the order in the *Problem Window*.	This will allow you to examine the *Late Order Reasons* report (See FIGURE 17).
Select the *Late Order Reasons* option from the *Reports* menu in the *Main Window*.	This provides an alternate way to examine the *Late Order Reasons* report.
Close the *Late Order Reasons*, *Demand Order Plan*, and *Manufacturing Order Plan* windows.	
In the *Problem Window*, click on the box next to *Late Orders*.	This will hide the list of *Late Orders*.
Click on the *Close* button to close the *Problem Window*.	

FIGURE 15 Late Orders - Demand Order Plan



Parts	Required	Short	Source	Planned	Inventory	Procure	WIP	Routing	EPST	PST
- SPCL_TABLE	100.00	0.00	ORDER_25-MFG00000	75.00	25.00	0.00	25.00	TABLE_ASSY	03/11/95 19:10	03/11/95 19:10
NAIL	800.00	0.00	inventory		800.00	0.00	0.00			03/01/95 00:00
GLUE	20.00	0.00	inventory		20.00	0.00	0.00			03/01/95 00:00
- LEG	200.00	0.00	ORDER_25-MFG00001	50.00	150.00	0.00	0.00	LEG	03/01/95 00:00	03/11/95 15:50
WOOD	50.00	0.00	inventory		50.00	0.00	0.00			03/01/95 00:00
- SPCL_TABLE_TOP	50.00	0.00	ORDER_25-MFG00002	50.00	0.00	0.00	0.00	TOP	03/11/95 00:00	03/11/95 00:00
LAMINATE	50.00	0.00	inventory		50.00	0.00	0.00			03/11/95 00:00
PARTICLE_BOARD	50.00	0.00	inventory		50.00	0.00	0.00			03/11/95 00:00
GLUE	5.00	0.00	inventory		5.00	0.00	0.00			03/11/95 00:00

FIGURE 16 Late Orders - Manufacturing Order Plan

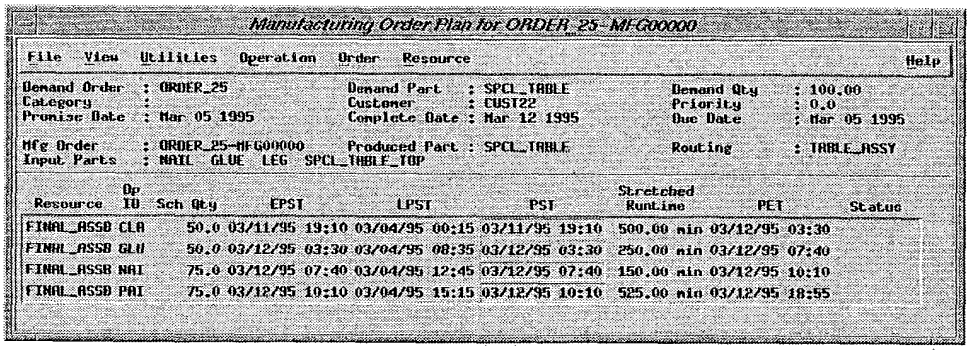
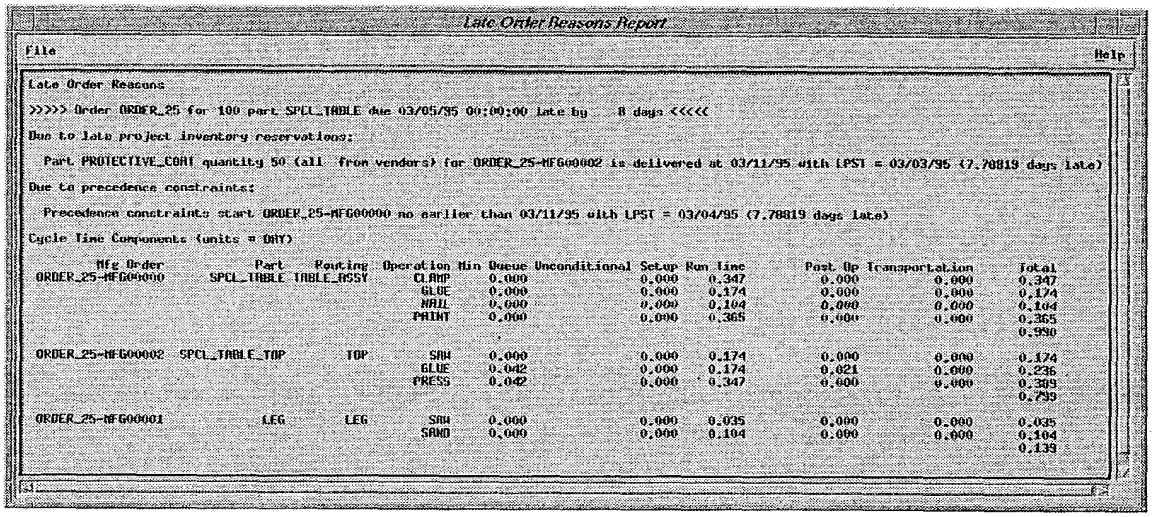


FIGURE 17 Late Order Reasons Report

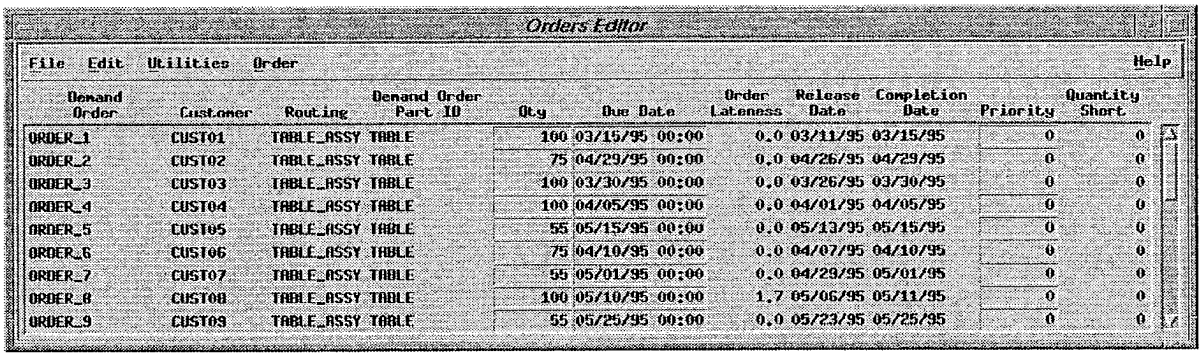


2.6 Lesson 4 - Editing

The *Edit* menu on the *Main Window* allows the user to change the factory model.

Select the *Orders* option from the *Edit* menu on the *Main Window*.	This opens the *Orders Editor* (See FIGURE 18). Fields which are in boxes may be changed if desired (e.g., *Qty* or *Due Date*). Other fields may not be changed.
Select the *Insert* option from the *Edit* menu.	The *Insert Order* window appears. This will allow you to add a new order to the plan (See FIGURE 19).
Change the order no. under *Demand Order* to a unique no.	
Change the part, quantity, due date, and priority.	Optional.
Click on the *OK* button.	The order will be inserted into the plan and *Rhythm*® will compute PSTs and a planned completion date.
Click on an order to be removed from the plan.	The order will become highlighted (selected).
Select the *Delete* option from the *Edit* menu.	A confirmation dialog will appear (See FIGURE 20).
Select the *Parts* option from the *Edit* menu on the *Main Window*.	This opens the *Parts Editor* (See FIGURE 21).
Select options from the *View* menu (See FIGURE 22).	These options allow you to view selected categories of parts.
Select options from the *Part* menu (See FIGURE 23).	These options allow you to access other relevant windows.
Select the *Resources* option from the *Edit* menu on the *Main Window*.	This opens the *Resources Editor* (See FIGURE 24). Fields which are in boxes may be changed if desired.
Select options from the *Resource* menu.	These options allow you to access other relevant windows.
Close the *Orders Editor* and *Parts Editor*.	

FIGURE 18 Orders Editor



Demand Order	Customer	Routing	Demand Order Part ID	Qty	Due Date	Order Lateness	Release Date	Completion Date	Priority	Quantity Short
ORDER_1	CUST01	TABLE_ASSY	TABLE	100	03/15/95 00:00	0.0	03/11/95	03/15/95	0	0
ORDER_2	CUST02	TABLE_ASSY	TABLE	75	04/29/95 00:00	0.0	04/26/95	04/29/95	0	0
ORDER_3	CUST03	TABLE_ASSY	TABLE	100	03/30/95 00:00	0.0	03/26/95	03/30/95	0	0
ORDER_4	CUST04	TABLE_ASSY	TABLE	100	04/05/95 00:00	0.0	04/01/95	04/05/95	0	0
ORDER_5	CUST05	TABLE_ASSY	TABLE	55	05/15/95 00:00	0.0	05/13/95	05/15/95	0	0
ORDER_6	CUST06	TABLE_ASSY	TABLE	75	04/10/95 00:00	0.0	04/07/95	04/10/95	0	0
ORDER_7	CUST07	TABLE_ASSY	TABLE	55	05/01/95 00:00	0.0	04/29/95	05/01/95	0	0
ORDER_8	CUST08	TABLE_ASSY	TABLE	100	05/10/95 00:00	1.7	05/06/95	05/11/95	0	0
ORDER_9	CUST09	TABLE_ASSY	TABLE	55	05/25/95 00:00	0.0	05/23/95	05/25/95	0	0

FIGURE 19 Insert Order

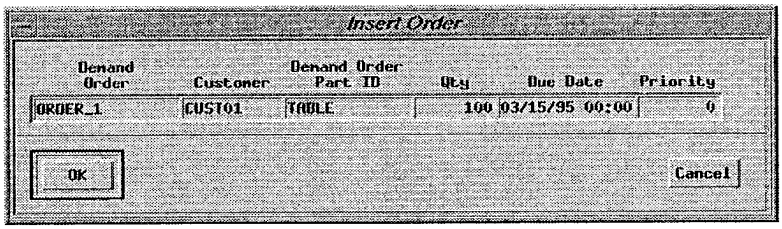


FIGURE 20 Delete Confirmation

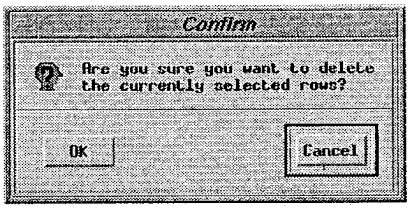


FIGURE 21 Parts Editor

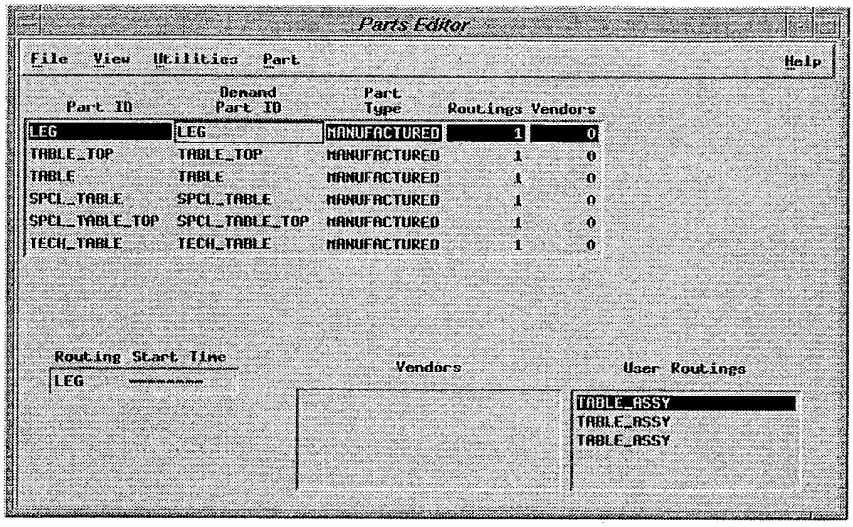


FIGURE 22 Parts Editor - View Menu

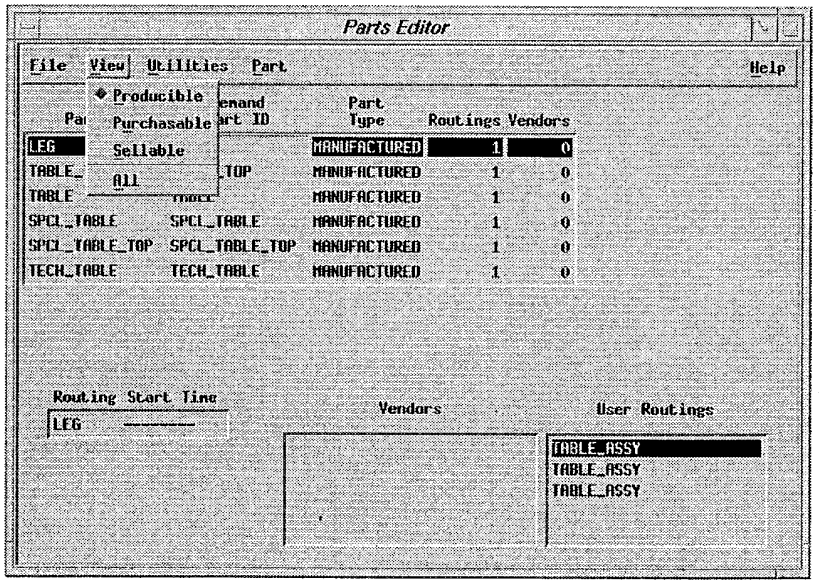


FIGURE 23 Parts Editor - Part Menu

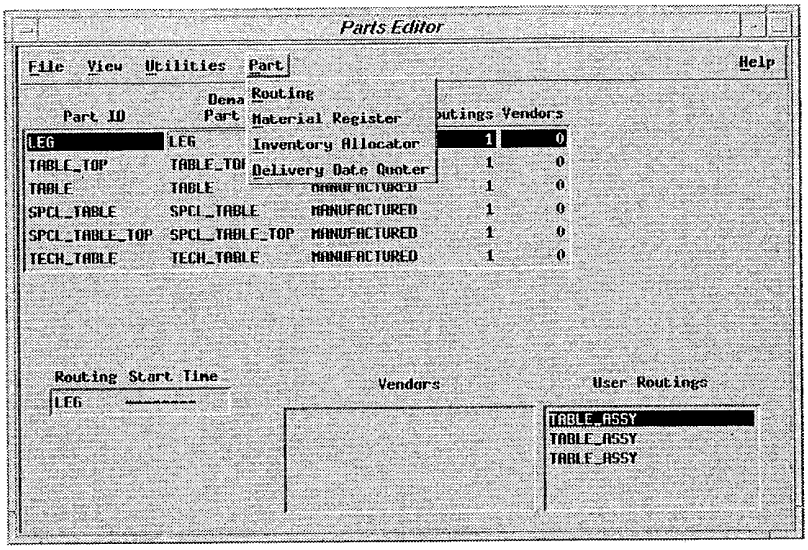
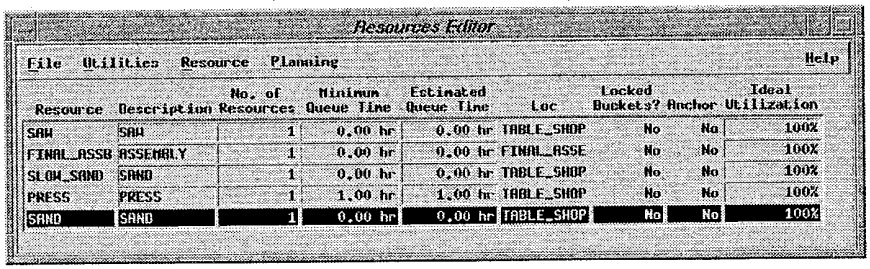


FIGURE 24 Resources Editor

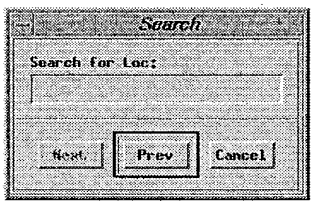


2.7 Lesson 5 - Sorting and Searching

Let's sort the *Resources Editor* by resource. The sort field, in this case *Resource*, should be visible.

Place the pointer over the *Resource* column title.	
Press and hold the right mouse button.	A pop up menu appears.
Drag the pointer to the *Ascending* option, and release the mouse button.	Now the list is sorted by resource.
Place the pointer over the *Loc* column title.	
Press and hold the right mouse button.	A pop up menu appears.
Drag the pointer to the *Search* option, and release the mouse button.	A dialog window appears (See FIGURE 25).
Click in the dialog box.	
Enter a *Loc*.	The program searches interactively, as you enter each character, to find the next location that matches the string input up to that point. The location becomes highlighted in the *Resources Editor*.
Click on the *Cancel* button.	The *Search* window is closed.

FIGURE 25 Search for Order



2.8 Lesson 6 - Customize Layout

The matrix windows throughout *Rhythm*® may be customized to show more or less information. Many of the views you have already seen may be customized by selecting *Customize Layout* from the *Utilities* menu within a view. Let us see how this capability works for the *Unscheduled Operations* list in the *Resource Editor* window.

Select the *Resource* menu in the *Resources Editor* window.	
Select the *Unscheduled Operations* option.	The *Unscheduled Operations* window will appear. See FIGURE 26.
Select *Customize Layout* from the *Utilities* menu.	This opens the *Customize Layout* window (See FIGURE 27). On the left are fields which are *Available*, meaning they are not currently visible but can be added to the data view. On the right are fields which are *Selected*, meaning they are already in the data view but can be removed.
Using the vertical scroll bar, scroll through the list of *Available* fields until you see *Due Date*.	
Select the *Due Date* field from the *Available* list (See FIGURE 28).	*Due Date* will appear highlighted, and its description will appear in the *Description* box.
Click on the right arrow located between the *Available* and *Selected* lists.	The highlighted field (*Due Date* in this case) will be added to the end of the *Selected* list.
Using the vertical scroll bar, scroll through the list of *Selected* fields until you see *Due Date*.	
Select the *Due Date* field from the *Selected* list (See FIGURE 29).	*Due Date* will appear highlighted, and its description will appear in the *Description* box.
Repeatedly click the up and down arrows located below the *Selected* list.	This will allow you to move the highlighted field (*Due Date* in this case) to the position you desire (See FIGURE 30).
Click on the *OK* button.	The *Customize Layout* window is closed, and the new field (*Due Date*) is added to the *Unscheduled Operations* window. Note the change in the fields listed in the *Unscheduled Operations* list (See FIGURE 31).
Close the *Unscheduled Operations* and *Resources Editor* windows.	

Customizing data views in *Rhythm*® is just this easy!

FIGURE 26 Unscheduled Operations

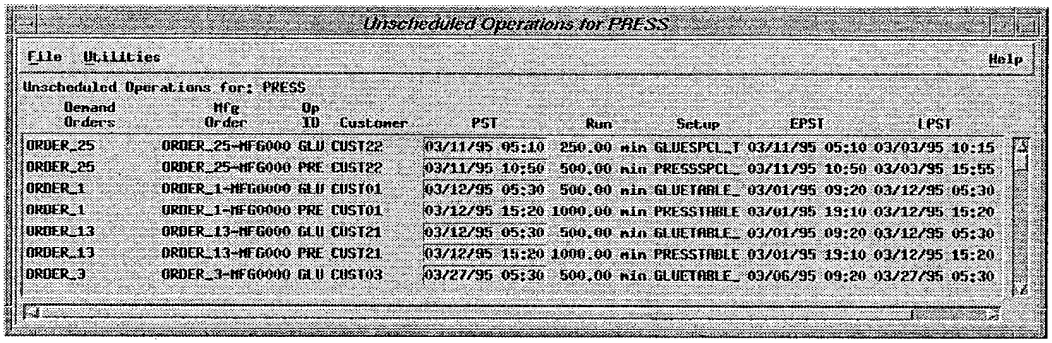


FIGURE 27 Customize Layout - Initial

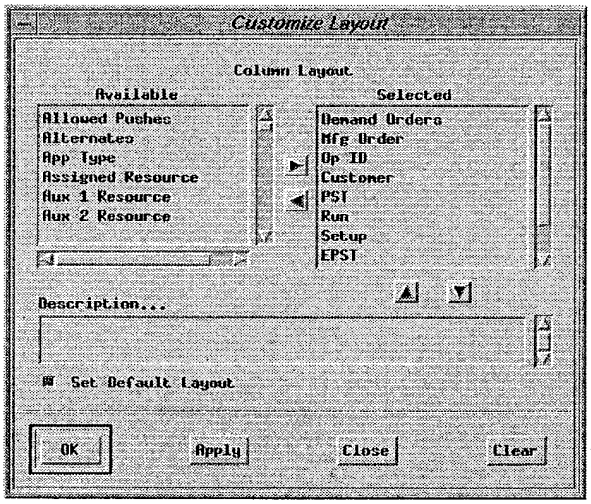


FIGURE 28 Customize Layout - Available

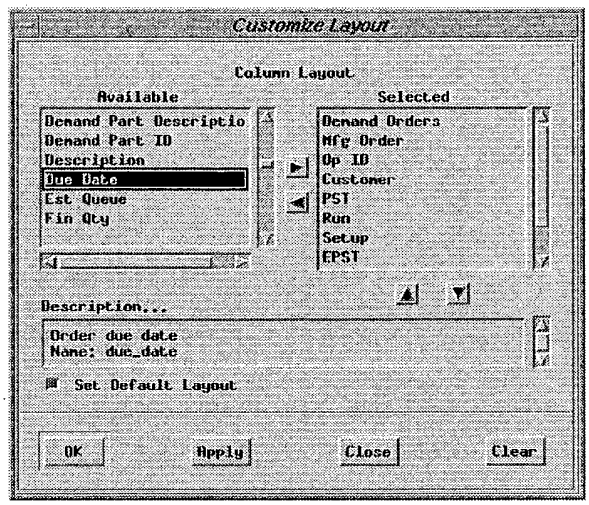


FIGURE 29 Customize Layout - Selected

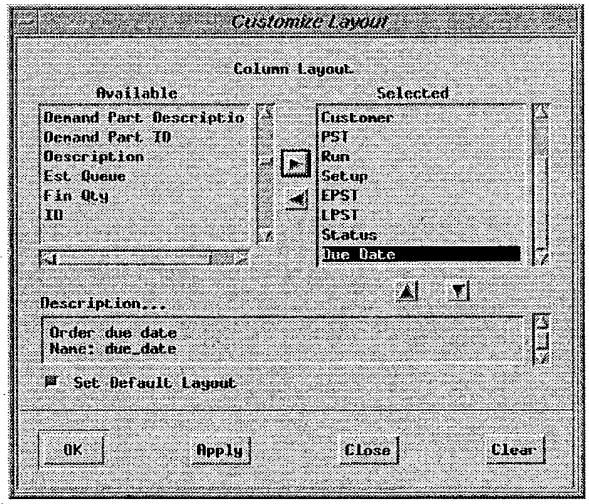


FIGURE 30 Customize Layout - Move Selection

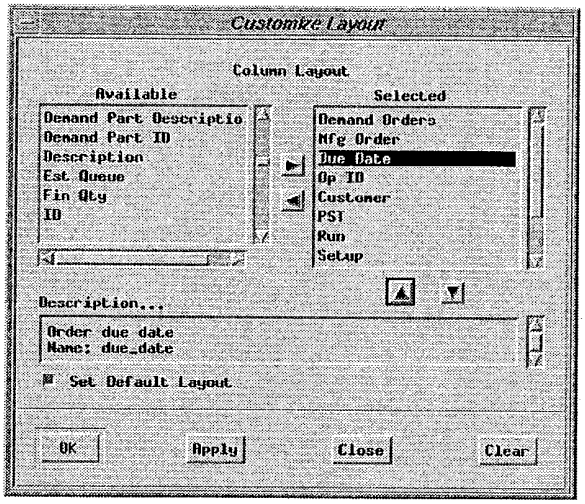
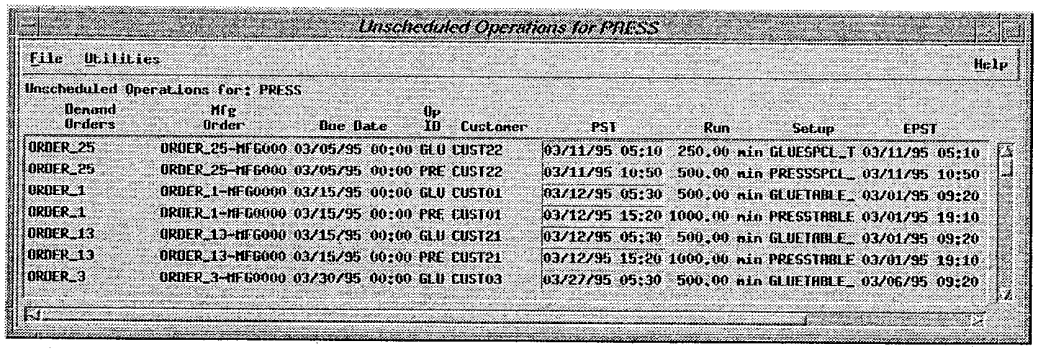


FIGURE 31 Unscheduled Operations - Customized



Demand Orders	Mfg Order	Due Date	Op ID	Customer	PST	Run	Setup	EPST
ORDER_25	ORDER_25-MFG000	03/05/95 00:00	GLU	CUST22	03/11/95 05:10	250.00 min	GLUESPCL_T	03/11/95 05:10
ORDER_25	ORDER_25-MFG000	03/05/95 00:00	PRE	CUST22	03/11/95 10:50	500.00 min	PRESSSPCL_	03/11/95 10:50
ORDER_1	ORDER_1-MFG0000	03/15/95 00:00	GLU	CUST01	03/12/95 05:30	500.00 min	GLUETABLE_	03/01/95 09:20
ORDER_1	ORDER_1-MFG0000	03/15/95 00:00	PRE	CUST01	03/12/95 15:20	1000.00 min	PRESSTABLE	03/01/95 19:10
ORDER_13	ORDER_13-MFG000	03/15/95 00:00	GLU	CUST21	03/12/95 05:30	500.00 min	GLUETABLE_	03/01/95 09:20
ORDER_13	ORDER_13-MFG000	03/15/95 00:00	PRE	CUST21	03/12/95 15:20	1000.00 min	PRESSTABLE	03/01/95 19:10
ORDER_3	ORDER_3-MFG0000	03/30/95 00:00	GLU	CUST03	03/27/95 05:30	500.00 min	GLUETABLE_	03/06/95 09:20

2.9 Lesson 7 - Resource Calendar

The *Resource Calendar* is used to define the net capacity (re: *Load Graph*) of each of the resources in the system. Times at which a resource is unavailable (such as for planned maintenance) can be entered via the *Resource Calendar.*

Select the *Resource Calendar* option from the *Utilities* menu on the *Main Window.*	This opens the *Resource Calendar* (See FIGURE 32).
In the list of *Unselected* resources, click on a resource to select it.	The resource will become highlighted (selected).
Click on the right (top) arrow button.	The resource will be moved to the list of *Selected* resources.
In the list of *Selected* resources, click on a resource to select (highlight) it.	The calendar pane will reflect the levels, in hours, of the capacity type selected for each day of the displayed month.
Click on the component button, and slide to the component to be displayed on the calendar.	The component may be selected as *Theoretical Capacity, Planned Maintenance, Unavailable Capacity, Rework Capacity, Net Capacity,* or *Setup Capacity.*
Click on the left and right arrowheads above the calendar pane.	This allows you to change the month being displayed in the calendar pane.
Select one or more days in the calendar pane by clicking on them (See FIGURE 33).	The day numbers selected are enclosed in a box.
Select *Unavailable Capacity* as the component.	
Change *Value* to 24.0.	
Click on the *Unit* button, and slide to *Hours*.	24 *Hours* are defined as *Unavailable Capacity* for the selected days.
Click on the *Apply* button.	Note that the changes are reflected in the summary pane.
	Note that changes entered by the user will be applied to all resources in the list of *Selected* resources, although the calendar pane will only show the capacity of the resource highlighted in the list of *Selected* resources.
Close the *Resource Calendar* by selecting *Close* from the *File* menu.	Normally you would save your changes, but do not do so in this case.
	Note that the component which is selected determines what values are displayed in the calendar pane, but that the summary pane at the bottom shows monthly totals for all components.

FIGURE 32 Resource Calendar - Initial

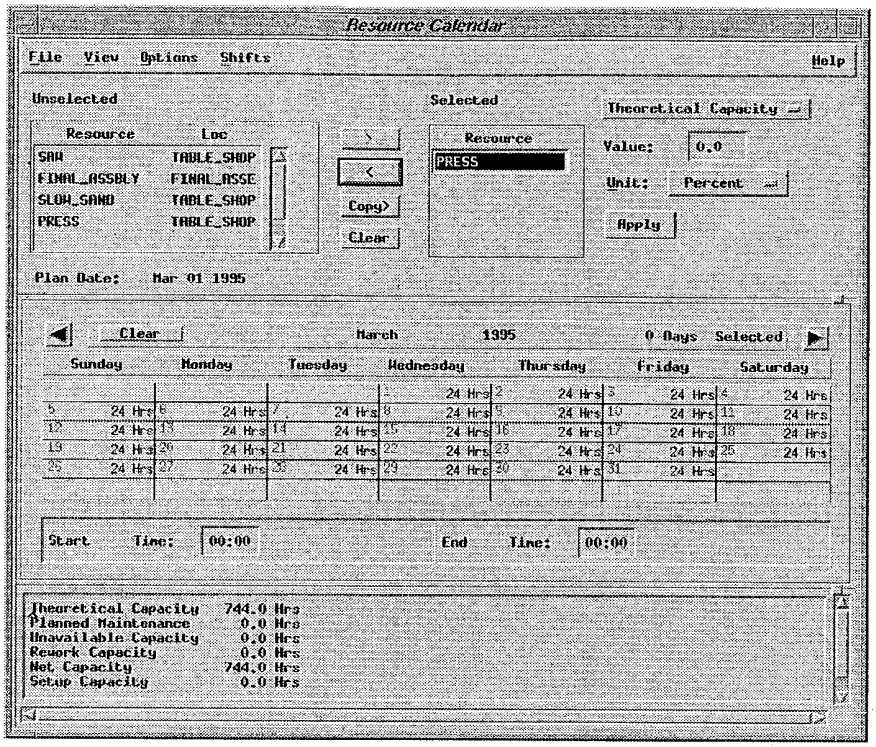
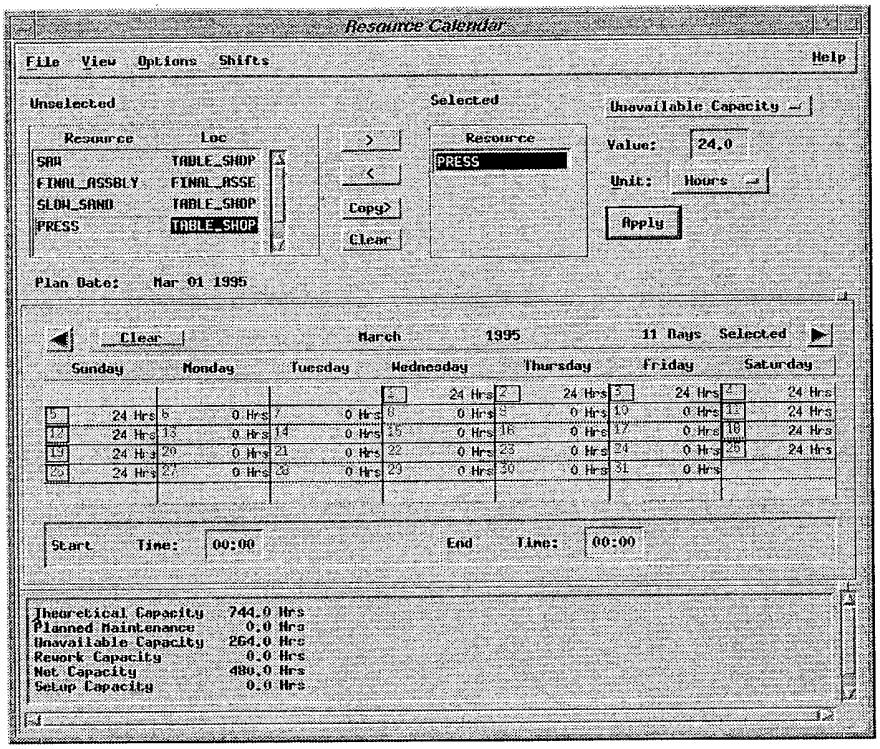


FIGURE 33 Resource Calendar



2.10 Lesson 8 - Delivery Date Quoter

The *Delivery Date Quoter* can be used to estimate the earliest time that a particular quantity of a part would be completed if a new order has to be entered.

Select *Delivery Date Quoter* from the *Utilities* menu in the *Main Window*.	The *Delivery Date Quoter* window appears (See FIGURE 34).
Enter an existing part number (See *Parts Editor*).	
Enter a new quantity for the part number (See FIGURE 35).	
Click on *Quote*.	This will show you when the new quantity for the part will complete (See FIGURE 36).
Click on *Insert Order*.	*Insert Order* window appears with default values from *Delivery Date Quoter* window.
Enter a valid order ID and customer name.	
Change quantity and due date (if want to).	See FIGURE 37.
Click on the *OK* button.	The order is added assuming infinite capacity with PST=LPST.
Click on the *Cancel* button in the *Delivery Date Quoter*.	

FIGURE 34 Delivery Date Quoter

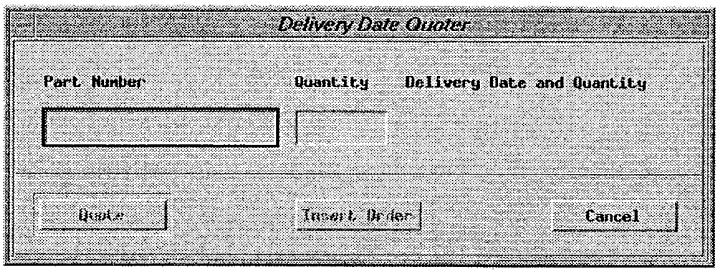


FIGURE 35 Delivery Date Quoter - Enter Values

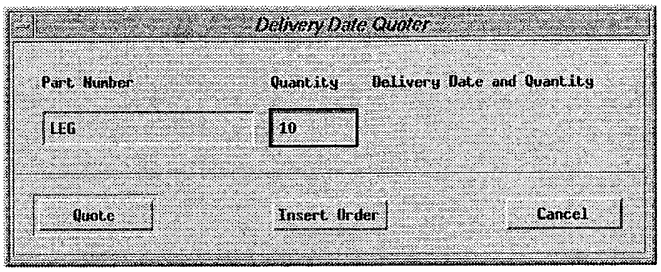
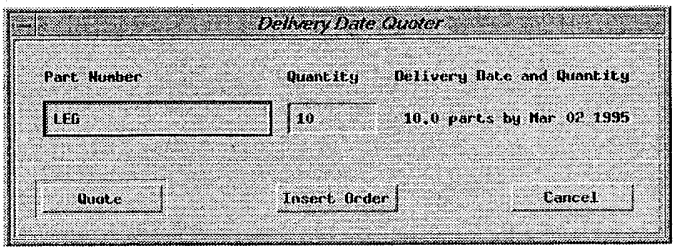
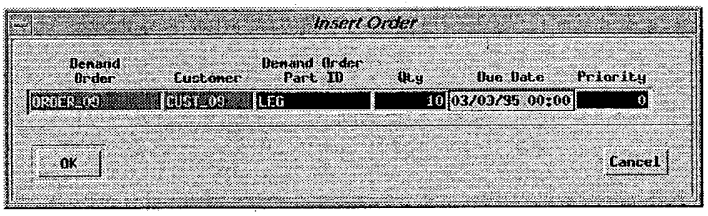


FIGURE 36 Delivery Date Quoter - Result



The *Delivery Date Quoter* examines the *Load Graph* for resources on the order's routing to determine the capacity availabilities for needed resources. Beginning at the first operation, it overlays the new requirement on the current plan. It also checks material availability.

FIGURE 37 Insert Order

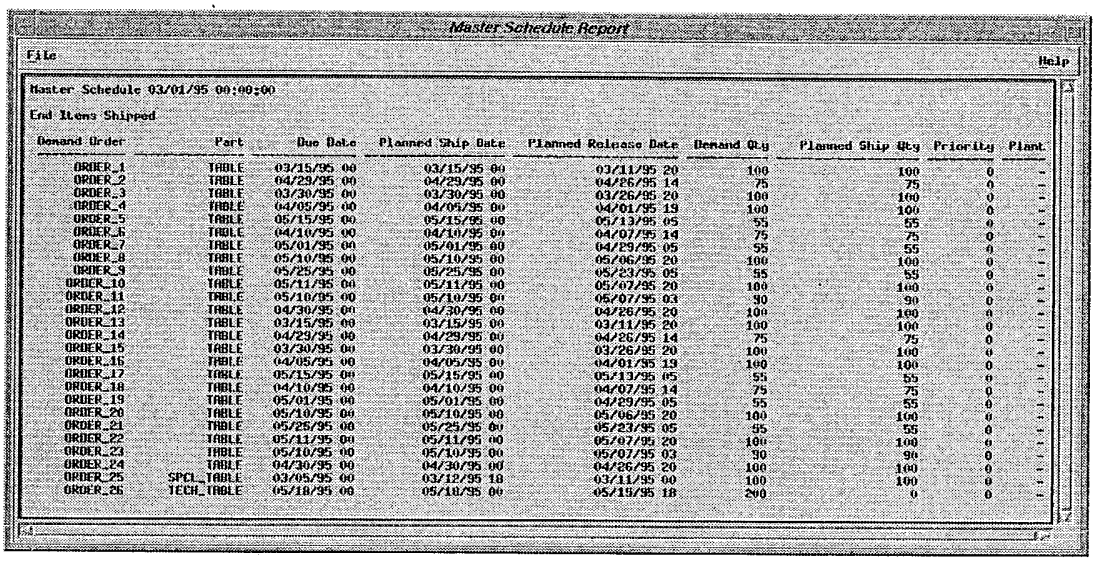


2.11 Lesson 9 - Reports

Select the *Master Schedule* from the *Reports* menu in the *Main Window* (See FIGURE 38).

This allows you to examine a report of the quantity of each demand order of parts assigned to demand orders.

FIGURE 38 Master Schedule



Demand Order	Part	Due Date	Planned Ship Date	Planned Release Date	Demand Qty	Planned Ship Qty	Priority	Plant
ORDER_1	TABLE	03/15/95 00	03/15/95 00	03/11/95 20	100	100	0	-
ORDER_2	TABLE	04/29/95 00	04/29/95 00	04/26/95 14	75	75	0	-
ORDER_3	TABLE	03/30/95 00	03/30/95 00	03/26/95 20	100	100	0	-
ORDER_4	TABLE	04/05/95 00	04/05/95 00	04/01/95 19	100	100	0	-
ORDER_5	TABLE	05/15/95 00	05/15/95 00	05/13/95 05	55	55	0	-
ORDER_6	TABLE	04/10/95 00	04/10/95 00	04/07/95 14	75	75	0	-
ORDER_7	TABLE	05/01/95 00	05/01/95 00	04/29/95 05	55	55	0	-
ORDER_8	TABLE	05/10/95 00	05/10/95 00	05/06/95 20	100	100	0	-
ORDER_9	TABLE	05/25/95 00	05/25/95 00	05/23/95 05	55	55	0	-
ORDER_10	TABLE	05/11/95 00	05/11/95 00	05/07/95 20	100	100	0	-
ORDER_11	TABLE	05/10/95 00	05/10/95 00	05/07/95 03	90	90	0	-
ORDER_12	TABLE	04/30/95 00	04/30/95 00	04/26/95 20	100	100	0	-
ORDER_13	TABLE	03/15/95 00	03/15/95 00	03/11/95 20	100	100	0	-
ORDER_14	TABLE	04/29/95 00	04/29/95 00	04/26/95 14	75	75	0	-
ORDER_15	TABLE	03/30/95 00	03/30/95 00	03/26/95 20	100	100	0	-
ORDER_16	TABLE	04/05/95 00	04/05/95 00	04/01/95 19	100	100	0	-
ORDER_17	TABLE	05/15/95 00	05/15/95 00	05/13/95 05	55	55	0	-
ORDER_18	TABLE	04/10/95 00	04/10/95 00	04/07/95 14	75	75	0	-
ORDER_19	TABLE	05/01/95 00	05/01/95 00	04/29/95 05	55	55	0	-
ORDER_20	TABLE	05/10/95 00	05/10/95 00	05/06/95 20	100	100	0	-
ORDER_21	TABLE	05/25/95 00	05/25/95 00	05/23/95 05	55	55	0	-
ORDER_22	TABLE	05/11/95 00	05/11/95 00	05/07/95 20	100	100	0	-
ORDER_23	TABLE	05/10/95 00	05/10/95 00	05/07/95 03	90	90	0	-
ORDER_24	TABLE	04/30/95 00	04/30/95 00	04/26/95 20	100	100	0	-
ORDER_25	SPCL_TABLE	03/05/95 00	03/12/95 18	03/11/95 00	100	100	0	-
ORDER_26	TECH_TABLE	05/18/95 00	05/18/95 00	05/15/95 18	200	0	0	-

2.12 Lesson 10 - Views

So far, we have always had a resource-centered view of the factory model. *Rhythm*® allows you to view the factory model from various perspectives.

In the *View* menu on the *Main Window*, select *Product* (See FIGURE 39).	This allows you to view the factory model from a product-centered (part-centered) perspective.
In the *View* menu on the *Main Window*, select *Customer* (See FIGURE 40).	This allows you to view the factory model from a customer-centered perspective.
Click on a customer in the *Select Customer* list, then click on the *List Products* button.	The list of products for this customer is displayed in the the *Select Product* list.
In the *View* menu on the *Main Window*, select *Graphical Resources* (See FIGURE 41).	This allows you to graphically view the shop floor at the resource level.
Click on a location in the *Select Location* list, then click on the *List Resources* button.	The list of resources for this location is displayed graphically.
In the *View* menu on the *Main Window*, select *Graphical Locations* (See FIGURE 42).	This allows you to graphically view the shop floor at the location level.

FIGURE 39 View Product

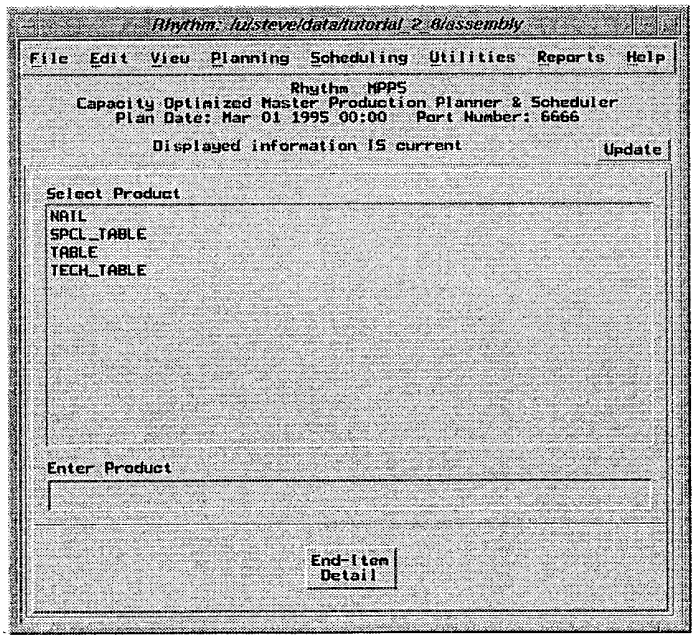


FIGURE 40 View Customer

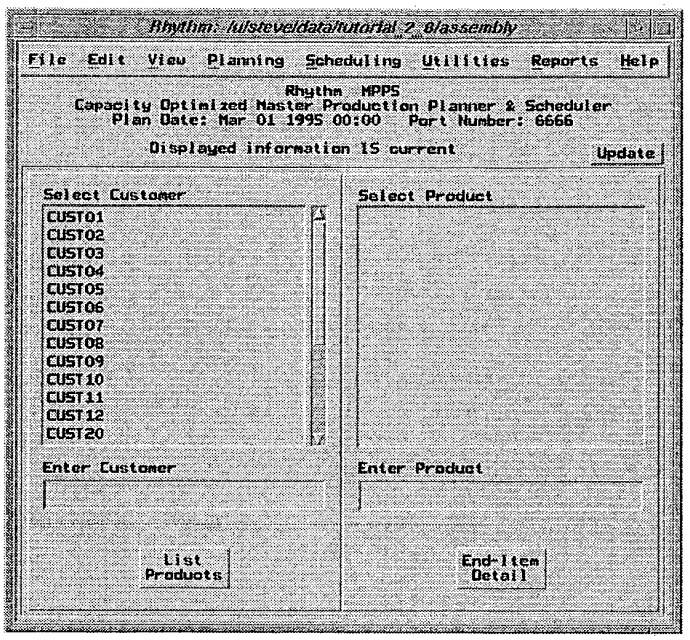


FIGURE 41 View Graphical Resources

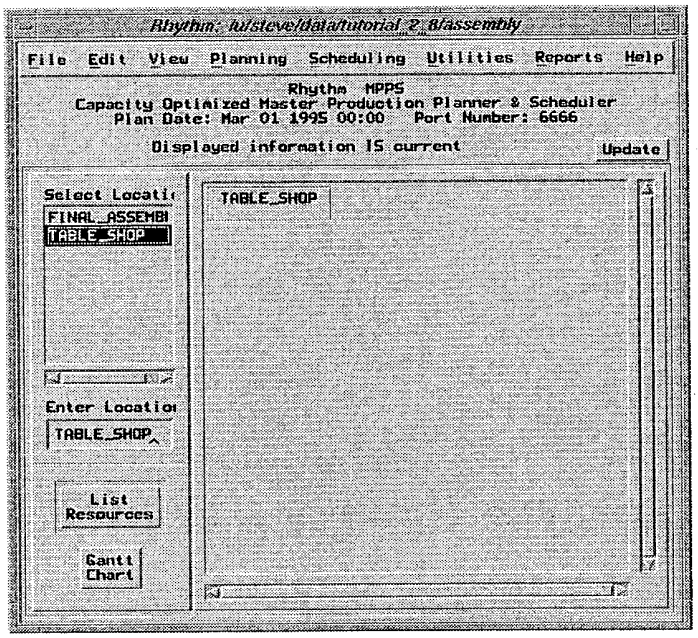
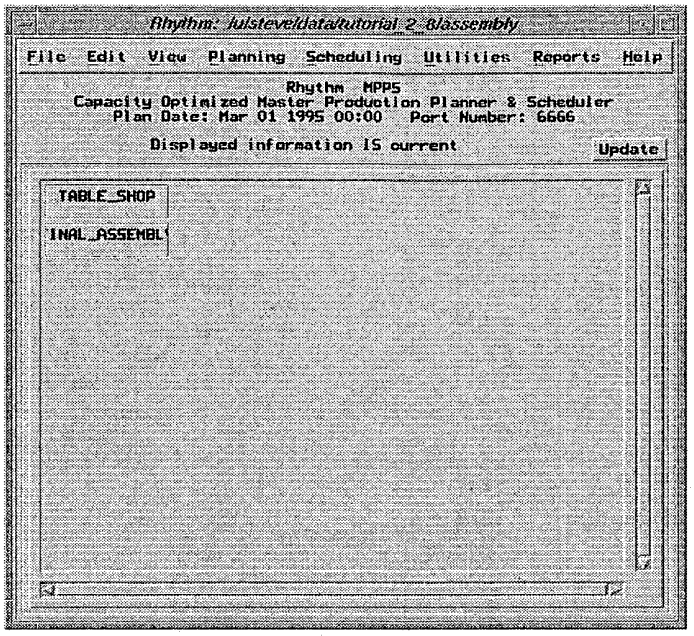


FIGURE 42 View Graphical Locations



2.13 Lesson 11 - Shutdown

Before you shutdown, decide what processes you want to terminate:

- just your client
- all clients and the server

Select *Exit* from the *File* menu in the *Main Window*.	A confirmation dialog will appear (See FIGURE 43). If you click on *OK*, this terminates just your client. In a multi-user situation, you normally will want to terminate your client but leave the server running.
Select *Shutdown Server* from the *File* menu in the *Main Window*.	A confirmation dialog will appear (See FIGURE 44). If you click on *OK*, a notification message will appear (See FIGURE 45), and the server and all clients connected to this server, including your own client, terminate.

FIGURE 43 Exit Client

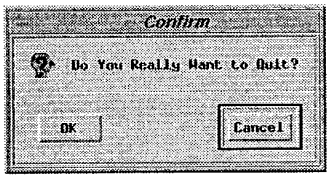


FIGURE 44 Shutdown Server

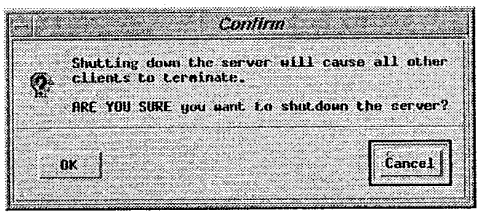
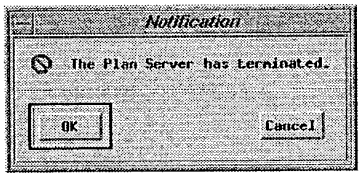


FIGURE 45 Shutdown Notification



2.14 Review

We have covered the following functionality in this section:

- *Rhythm® Main Window*
- *Load Graphs*
- *Problem Window*
- Responding to capacity shortages, late orders, and short orders
- *Resource Calendar*
- *Rhythm®* reports
- Customization of data views
- Sorting and searching in data views
- Order Due Date quotation
- Views
- Shutdown procedures

Section 3

CAO Guide

CAO™, a technology which focuses on constraint anchored optimization, is the scheduling procedure in *Rhythm®* that considers capacity to build schedules around anchors. An anchor is a resource with important scheduling objectives. An anchor is the place where you start building your plan or schedule. Examples of anchors include:

- Resources needing high utilization for which a significant chance of starvation or clogging exists
- Resources which have difficulty meeting setup guidelines or material synchronization requirements
- Batch resources which have difficulty meeting loading guidelines
- Assembly stations

CAO™ iterates through a four-step process:

1. Find anchor resources. If balancing is complete, stop.
2. Compute the criticality of all anchors and select the most critical anchor.
3. Balance the most critical anchor using the specified pull-push rule
4. Propagate and post constraints to other affected resources. Go to Step 1.

3.1 Training Objectives

After completing this section, you should:

- Be able to automatically balance the resource load for a single resource
- Be able to automatically optimize resource loads for all resources by using *CAO™*

3.2 Lesson 12 - CAO

At this point, you should have only two windows on your screen, the *Main Window* and the *Problem Window*. Close other windows.

View the list of *Capacity Shortages* by clicking on the appropriate box in the *Problem Window* (See FIGURE 46).

Click on each resource listed.

This will open *Load Graphs* for all over utilized resources (See FIGURE 47 and additional *Load Graphs*).

Using the scroll bar at the bottom of each *Load Graph*, display the bucket where the peak load occurs for each resource.

Arrange the *Load Graphs* on the screen for maximum visibility.

FIGURE 46 Capacity Shortages

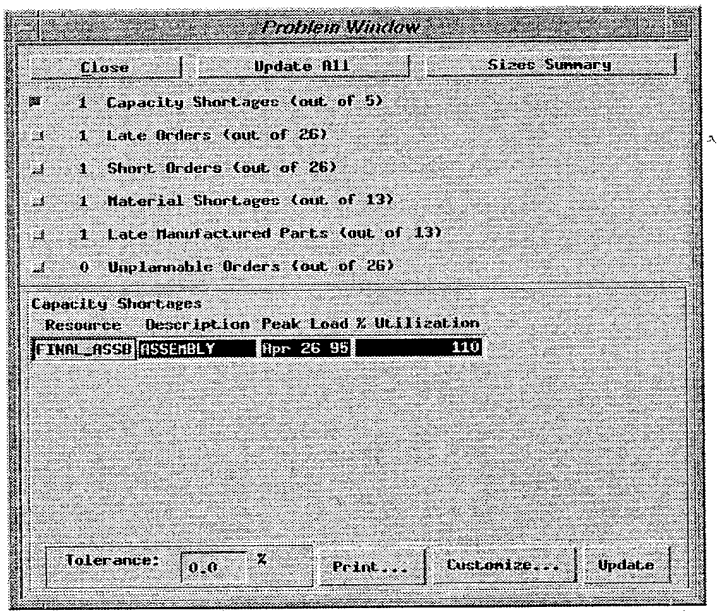
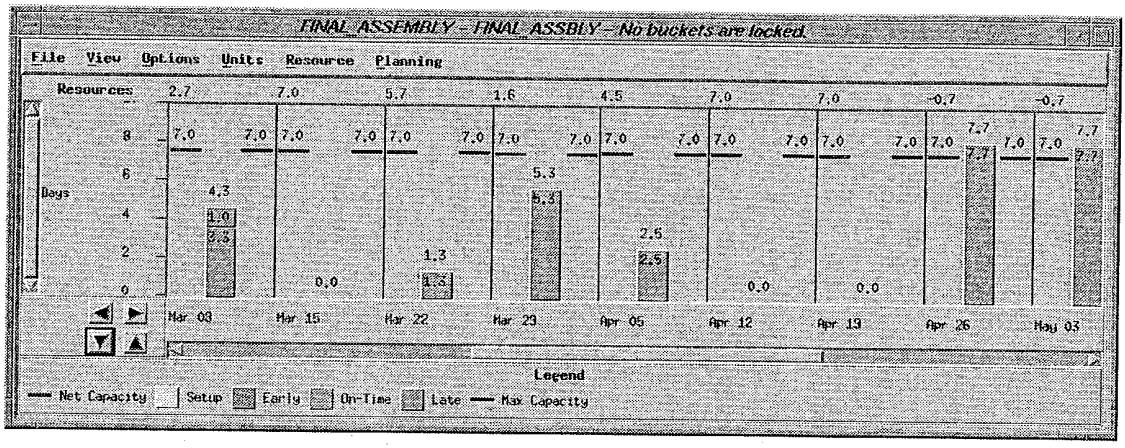


FIGURE 47 Load Graph - Anchor 1



We are now going to use *CAO™* to automatically balance the load on these resources by using push-pull balancing.

Select *CAO™* from the *Planning* menu in the *Main Window*.	The *CAO™* window will appear (See FIGURE 48).
	Note that the resources that were listed in the problem window are selected as anchors. These are the resources that *CAO™* will balance.
Select *Parameters* from the *CAO™* menu in the *CAO™* window	The *CAO™ Parameters* window will appear (See FIGURE 49).
	The settings for these parameters are important. They determine: 1) the objective function used to optimize the plan, and 2) the speed with which *CAO™* converges to a solution.
Click on the *Cancel* button.	This action keeps the default settings, and closes the *CAO™ Parameters* window.
Select *Run* from the *CAO™* menu.	This action executes *CAO™*.
Note the change in the list of resources in the *CAO™* window (See FIGURE 50).	*CAO™* has performed push-pull load balancing on the resources which were listed as anchors to generate a finite capacity plan.
	After *CAO™* runs, *Rhythm®* updates open *Load Graph* windows instantly.

Click on the *Update* button on the *Main Window.*	This allows you to see the effects of *CAO™*. The *Load Graph* windows which are open should change to reflect the new, balanced plan (See FIGURE 51 and additional *Load Graphs*. Compare these to the earlier *Load Graphs*).
Close the *Load Graphs* and *CAO™* window.	Note that the *Problem Window* has not changed. It needs to be updated.
Click on the *Update All* button on the *Problem Window.*	The *Problem Window* now shows any problems with the plan using the newly balanced *Load Graphs* (See FIGURE 52).

FIGURE 48 CAO

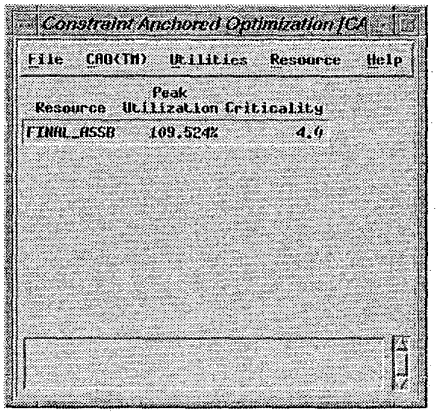


FIGURE 49 CAO Parameters

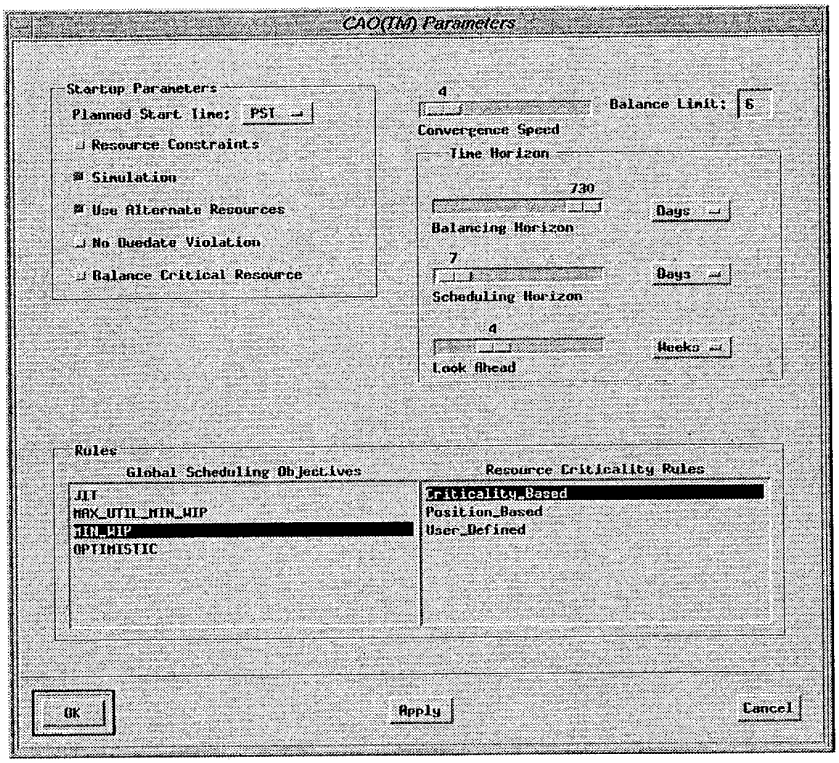


FIGURE 50 CAO - Resources After Run

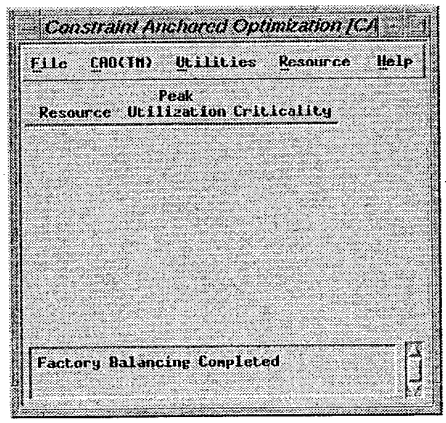


FIGURE 51 Load Graph - Anchor 1 Balanced

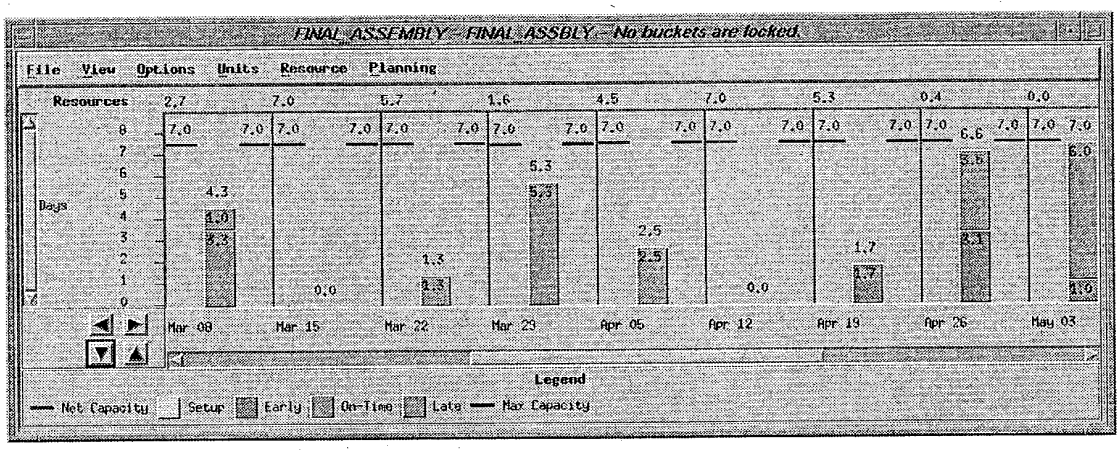
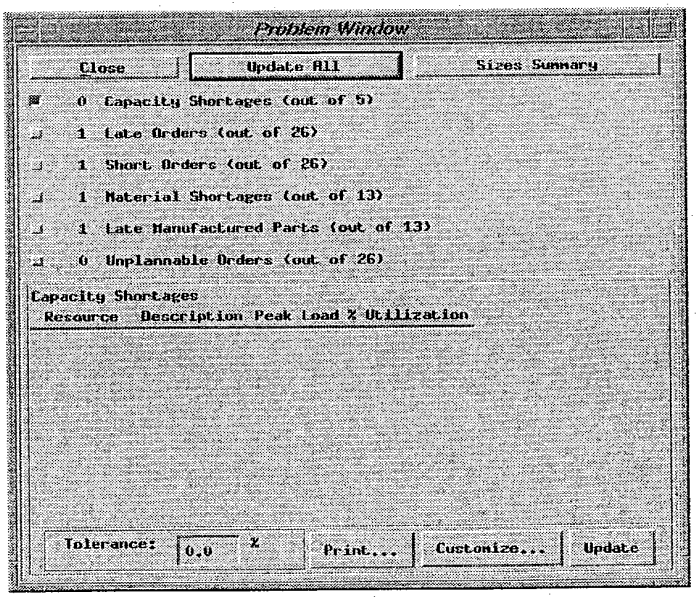


FIGURE 52 Capacity Shortages After CAO



3.3 Review

We have covered the following functionality in this section:

- Responding to capacity shortages
- Using *CAO™* to perform push-pull balancing

Section 4

DS Guide

Rhythm® DS is a schedule execution tool. It considers sequence dependent setup times, batching constraints, move times, domain specific priority and sequencing rules, and frozen sequences. It provides both Gantt chart and list-based interfaces.

DS begins with the plan from *Rhythm*® MPPS and sequences individual tasks within the buckets determined by MPPS to produce a detailed schedule. As an execution tool, it provides the capability to make on-line changes to the shop-floor schedule. It is designed for a short time horizon.

The detailed schedule may be generated automatically for all resources or interactively for individual resources.

4.1 Training Objectives

After completing this section, you should:

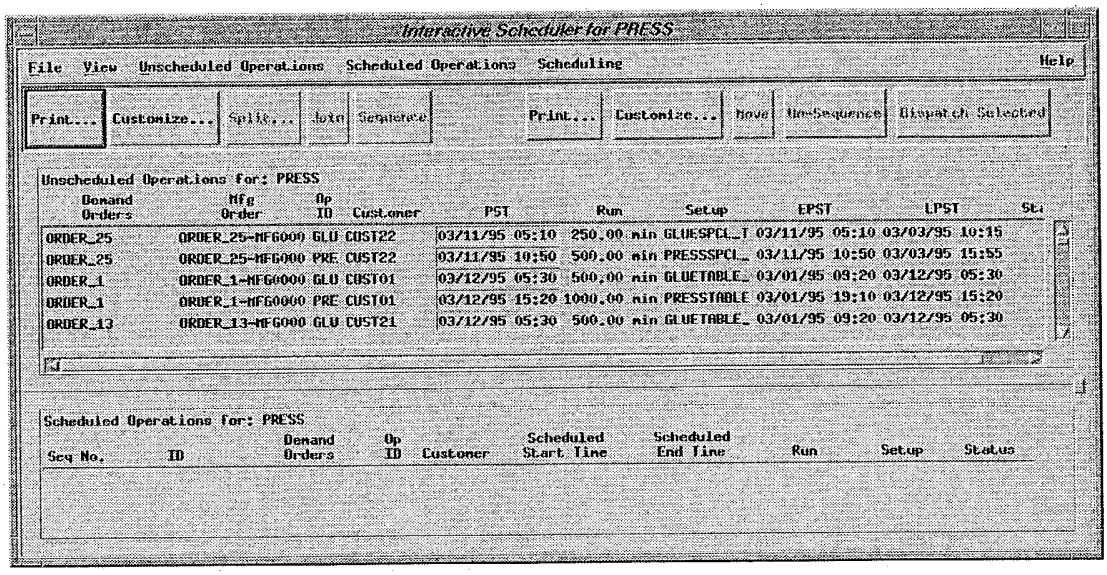
- Be familiar with the menus of the *Interactive Scheduler*
- Be able to customize views of data
- Be able to interactively schedule resources
- Be able to automatically schedule all resources
- Be able to split, join, and expedite orders
- Be able to examine *Gantt Charts*

4.2 Lesson 13 - Interactive Scheduler

The *Interactive Scheduler* window for a resource can be opened from several locations. For this exercise, we will open it from the *Main Window.*

Press and hold the right mouse button on a resource in the *Main Window.*	
Drag the pointer to the *Interactive Scheduling* option, and release the mouse button.	This opens the *Interactive Scheduler* window (See FIGURE 53).

FIGURE 53 Interactive Scheduler - Initial



4.3 Lesson 14 - Split and Join

Select the *Customize Layout* option from the *Unscheduled Operations* menu.	
Add the *Due Date* and *Order Qty* fields.	
Click on an order in the *Unscheduled Operations*.	The order will become highlighted (selected). See FIGURE 54.
Select the *Split* option from the *Unscheduled Operations* menu.	A dialog window appears (See FIGURE 55).
Enter the split quantity.	
Click on the *OK* button.	A new order will be created whose quantity is the difference between the order quantity and the split quantity.
Press and hold the right mouse button on the field title *Demand Orders*.	A pop up menu appears.
Drag the pointer to the option *Ascending*, and release the mouse button.	The orders will be sorted according to *Demand Order*.
Using the vertical scroll bar, scroll through the list of orders until you see the orders created by the split.	Note the quantities of the split order and the new order (See FIGURE 56).
Press and hold the left mouse button on one of the orders created by the split, and drag the pointer over the other order.	This highlights (selects) both of the orders.
Select the *Join* option from the *Unscheduled Operations* menu.	The previously split orders should be combined into the original order quantity.

FIGURE 54 Interactive Scheduler - Select Order

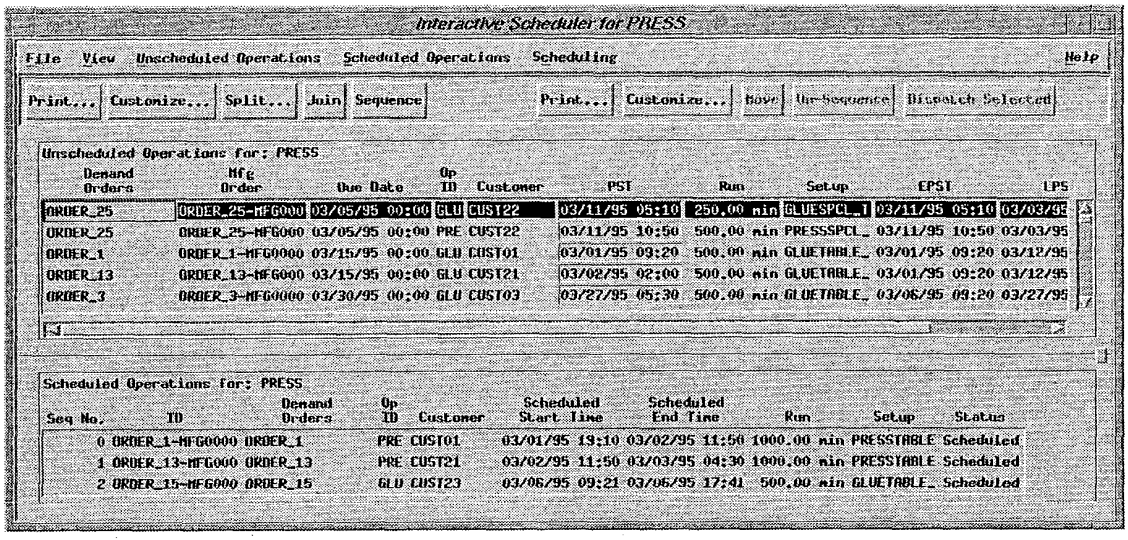


FIGURE 55 Split

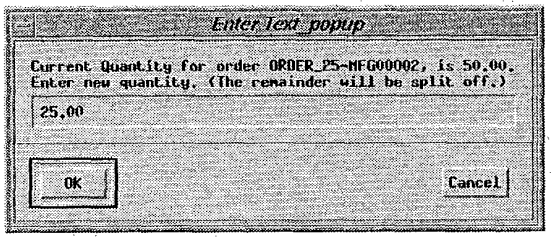
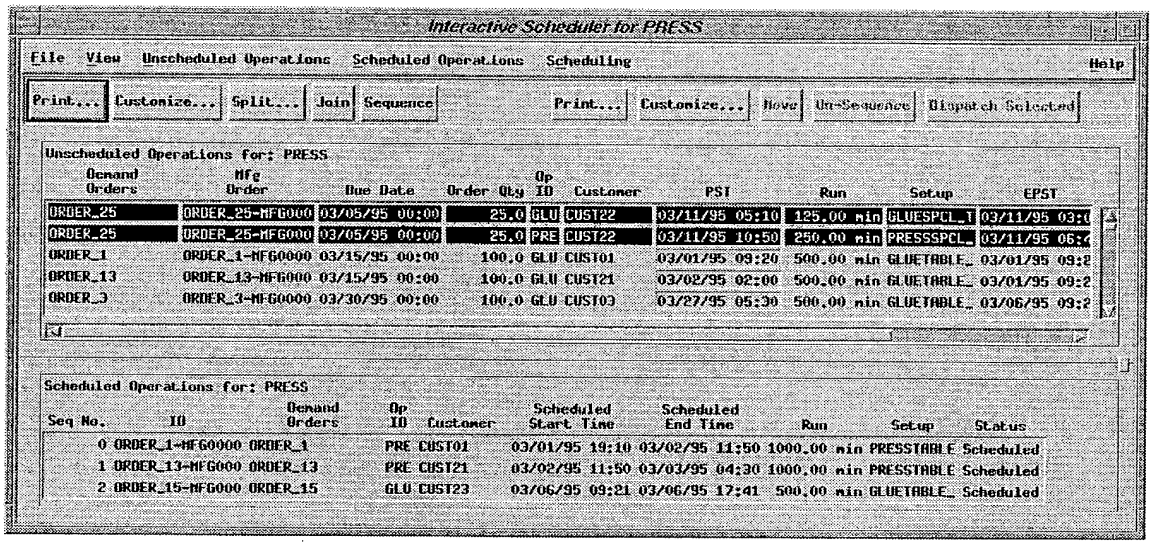


FIGURE 56 Interactive Scheduler - Split Order



4.4 Lesson 15 - Interactive Schedule Generation

Place the pointer over the *Due Date* column title.	
Press and hold the right mouse button.	A pop up menu appears.
Drag the pointer to the *Ascending* option, and release the mouse button.	Now the list is in earliest due date order.
Middle click on each order of interest in the *Unscheduled Operations* list that is to be scheduled.	The orders to be scheduled are highlighted (selected). See FIGURE 57.
Select the *Sequence* option from the *Unscheduled Operations menu*.	The selected orders are moved to the *Scheduled Operations* list (See FIGURE 58).
Click on an order whose position in the *Scheduled Operations* list is to be changed.	The order is highlighted (selected). See FIGURE 59.
Select the *Move* option from the *Scheduled Operations* menu.	The pointer changes to a finger.
Click on an order in the *Scheduled Operations* list.	The order being moved will be placed immediately before it. Note that the PSTs are recalculated (See FIGURE 60).
Click on an order in the *Scheduled Operations* list that is to be unsequenced.	The order is highlighted (selected).
Select the *Un-Sequence* option from the *Scheduled Operations* menu.	The order is moved to the *Unscheduled Operations* menu.

FIGURE 57 Interactive Scheduler - Schedule Orders

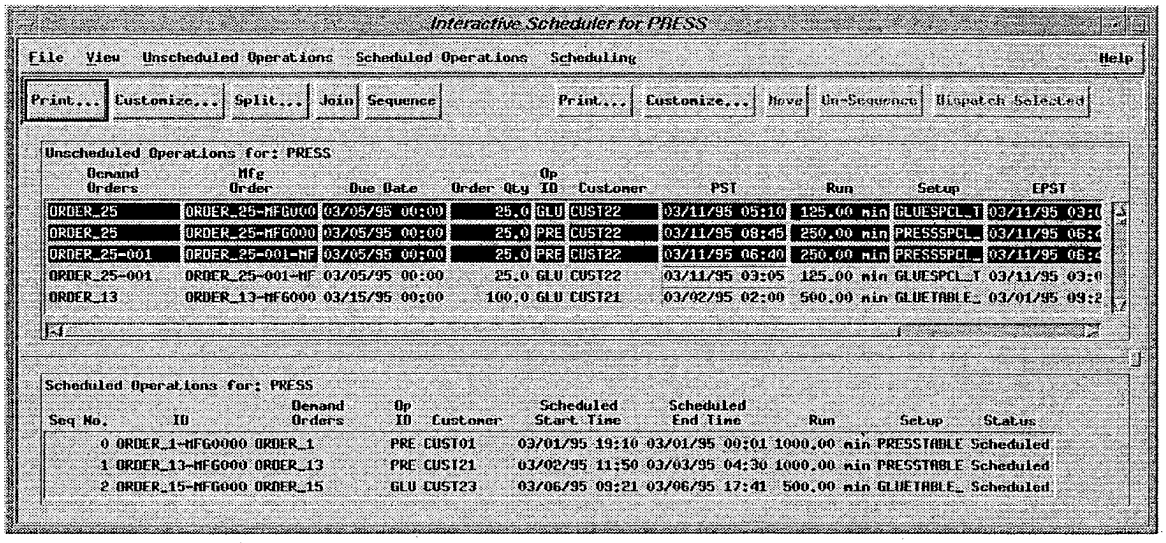


FIGURE 58 Interactive Scheduler - Orders Sequenced

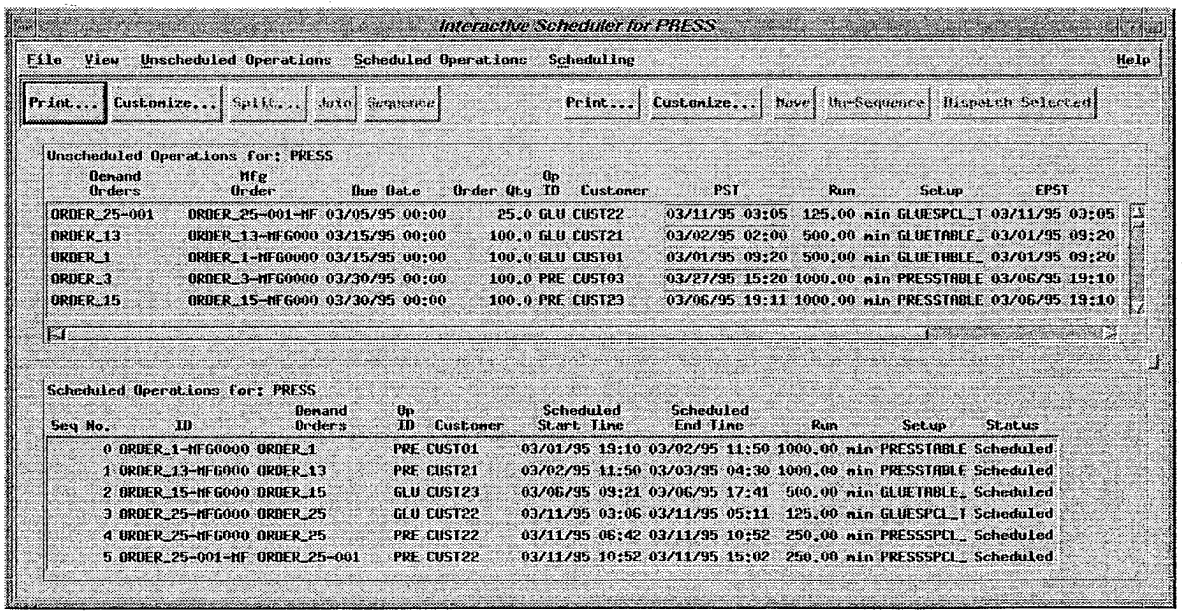


FIGURE 59 Interactive Scheduler - Move Order

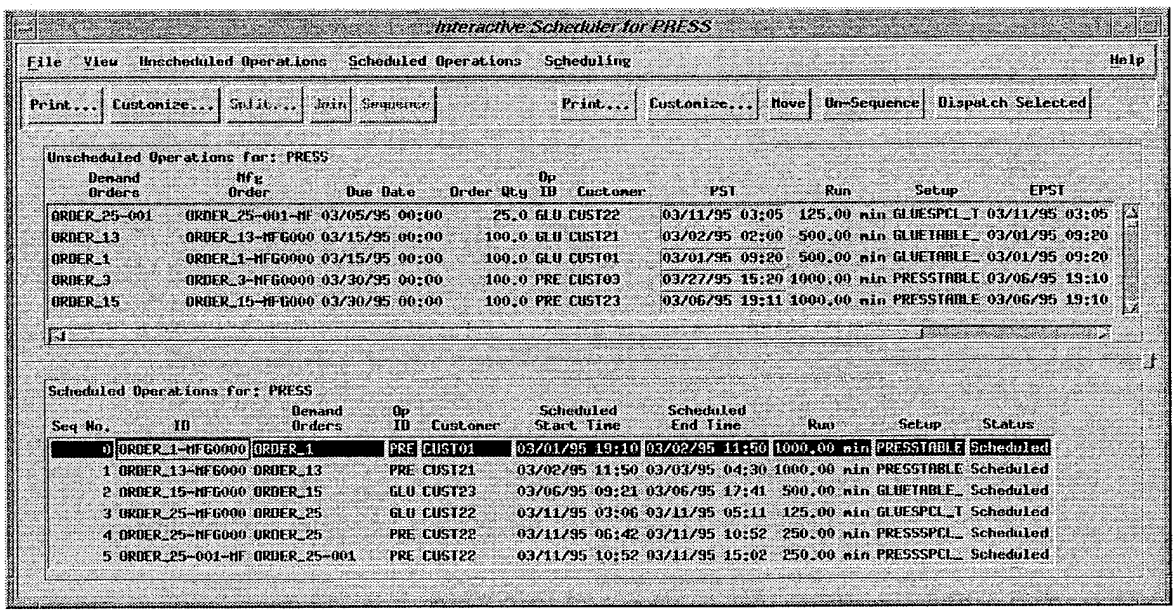
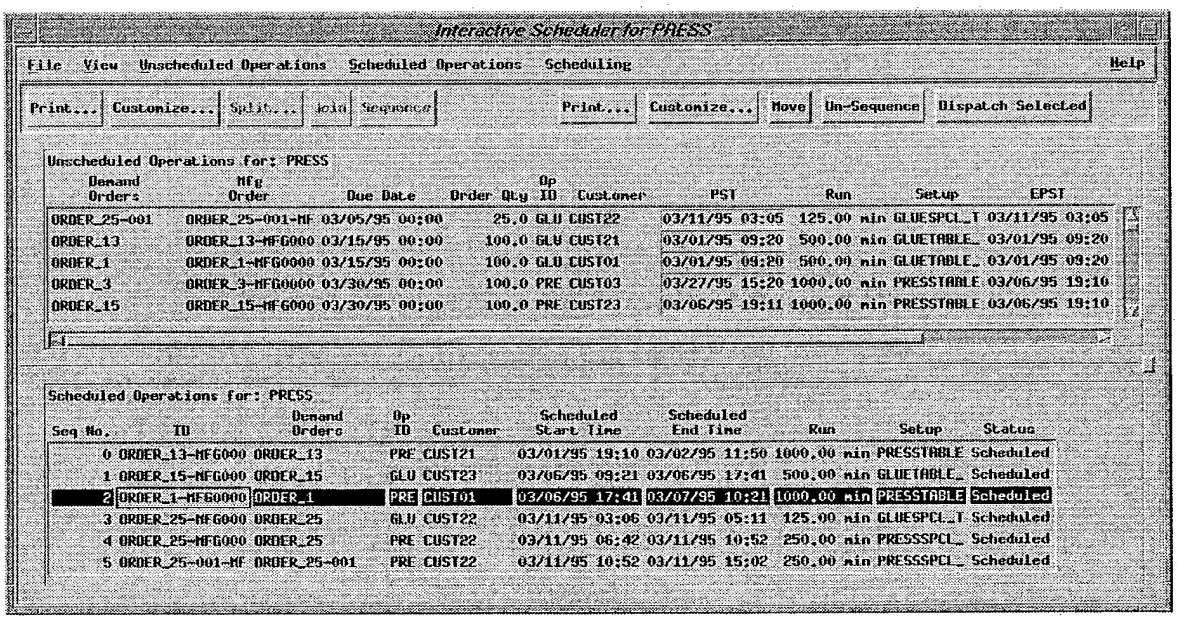


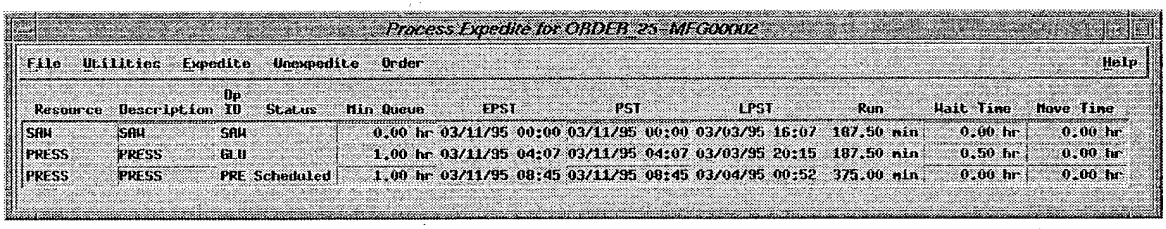
FIGURE 60 Interactive Scheduler - Order Moved



4.5 Lesson 16 - Expediting

Click on an order in the *Scheduled Operations* list that is to be expedited.	The order to be expedited is highlighted (selected).
Select the *Expedite* option from the *Scheduled Operations* menu.	The *Process Expedite* window for the order will appear (See FIGURE 61).
Change the order's queue time, PST, wait time, or move time.	This will expedite the order. Note that the effects of these changes are calculated immediately. For example, PSTs are updated.
Select the *Close* option from the *File* menu.	The *Process Expedite* window will close.

FIGURE 61 Expedite an Order



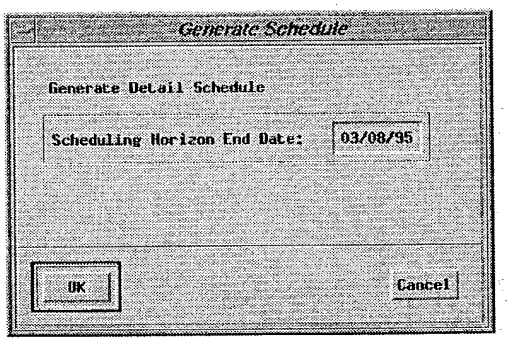
4.6 Lesson 17 - Automatic Schedule Generation

Select the *Generate Detail Schedule* option from the *Scheduling* menu on the *Main Window*.	The *Generate Schedule* dialog window will appear (See FIGURE 62).
Click in the dialog box for the *Scheduling Horizon End Date*.	
Enter the end date for the detailed schedule.	Note that the time required for the detailed schedule to be generated is a function of how far in the future the end date is.

When you enter values in the *Scheduling Horizon End Date*, the slashes separating month, day, and year are skipped when you enter numbers or when you move backward and forward with the left and right keyboard arrows. The *<Delete>* and *<Back Space>* keys on the keyboard are not functional in this dialog box. Entry of numbers overwrites displayed numbers.

☞ If you left the *Interactive Scheduler* window open while performing automatic scheduling, note that all orders are now in the *Scheduled Operations* list and they may be in a different order than they were when interactively scheduled.

FIGURE 62 Generate Detail Schedule

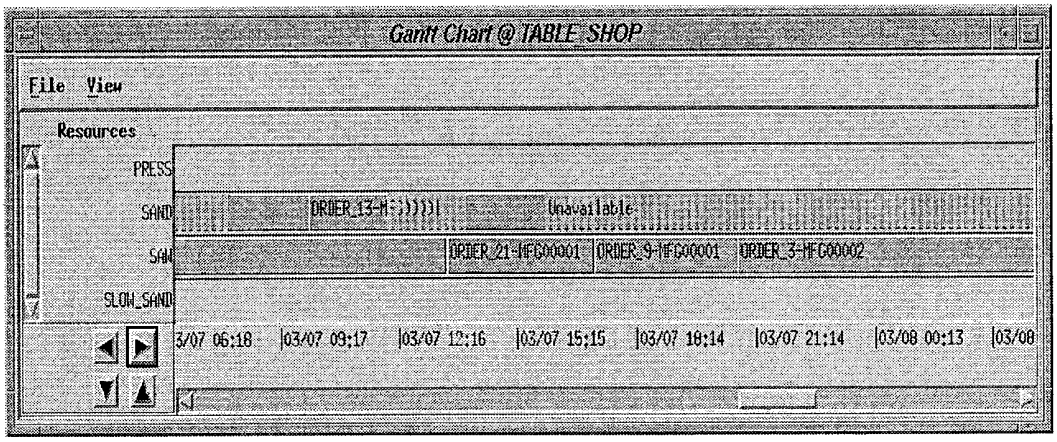


4.7 Lesson 18 - Gantt Chart

Gantt Charts for resources will be blank until the detailed schedule has been generated. Now that we have performed detailed scheduling, the *Gantt Charts* may be viewed.

In the *Main Window*, click on a location in the *Select Location* list.	The location will become highlighted (selected), and its name will appear in the *Enter Location* box (See FIGURE 2).
Click on the *Gantt Chart* button.	The *Gantt Chart* for all resources at that location will appear (See FIGURE 63). Note that all resources at a single location are listed in the *Gantt Chart*, but only those resources which have been scheduled have bars shown.
Select the *Close* option from the *File* menu.	The *Gantt Chart* will close.

FIGURE 63 Gantt Chart



4.8 Review

We have covered the following functionality in this section:

- Interactive scheduling and automatic scheduling
- Splitting and joining orders
- Expediting orders
- Gantt Charts

Section 5 Advanced Topics

This section introduces you to *Rhythm*® MPPS topics that are more challenging than the topics inroduced in preceding lessons.

5.1 Training Objectives

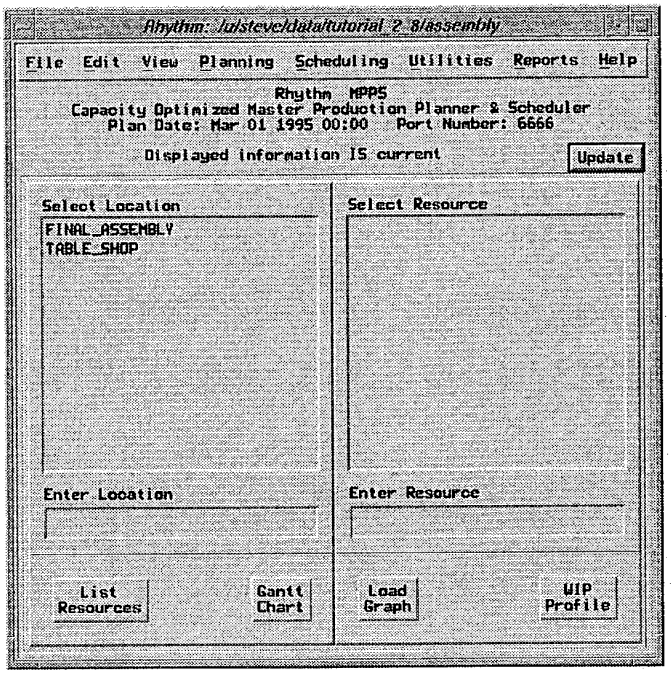
After completing this section, you should:

- Be able to manually move work in a resource *Load Graph* to different time buckets or alternate resources

5.2 Lesson 19 - Moving Load

If you have not already done so, start *Rhythm*® as described in the section titled *Starting Rhythm*®. The *Main Window* should be visible. See FIGURE 64.

FIGURE 64 Main Window - Initial



Click on a location in the *Select Location* list, click on the *List Resources* button, and click on a resource in the *Select Resource* list.

The location and resource will become highlighted (selected). See FIGURE 65.

Click on the *Load Graph* button (or press and hold the right mouse button on a resource in the *Select Resource* list, then slide to the *Load Graph* option).

A *Load Graph* for the resource is opened (See FIGURE 66).

Position the *Load Graph* under the *Main Window.*

Examine the work being performed during a bucket having tasks planned in it by clicking the middle button while the pointer is inside the bucket.

This opens the *Tasks Planned* window for the resource during this bucket (See FIGURE 67).

FIGURE 65 Main Window - Select Resource

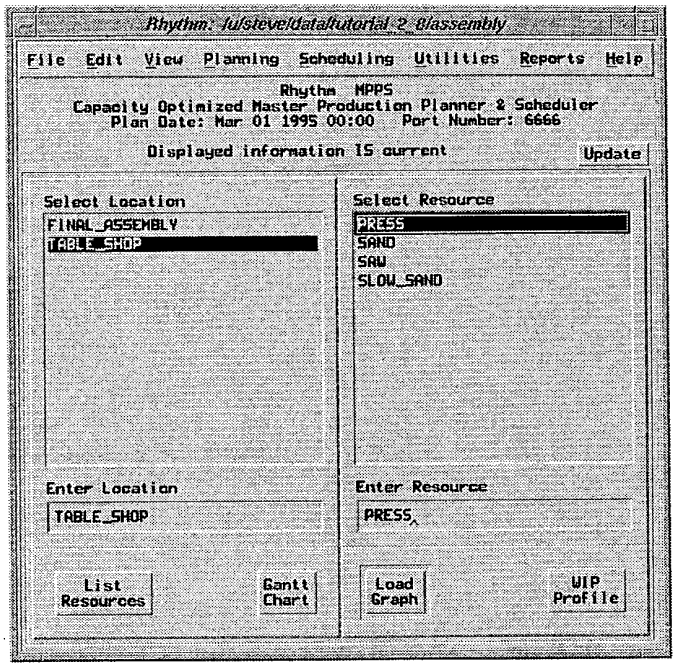


FIGURE 66 Load Graph (By Lateness)

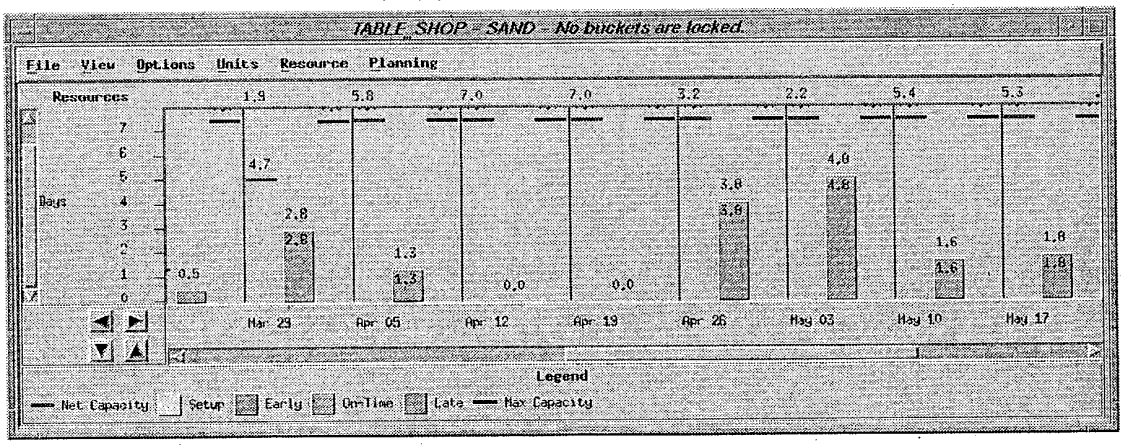
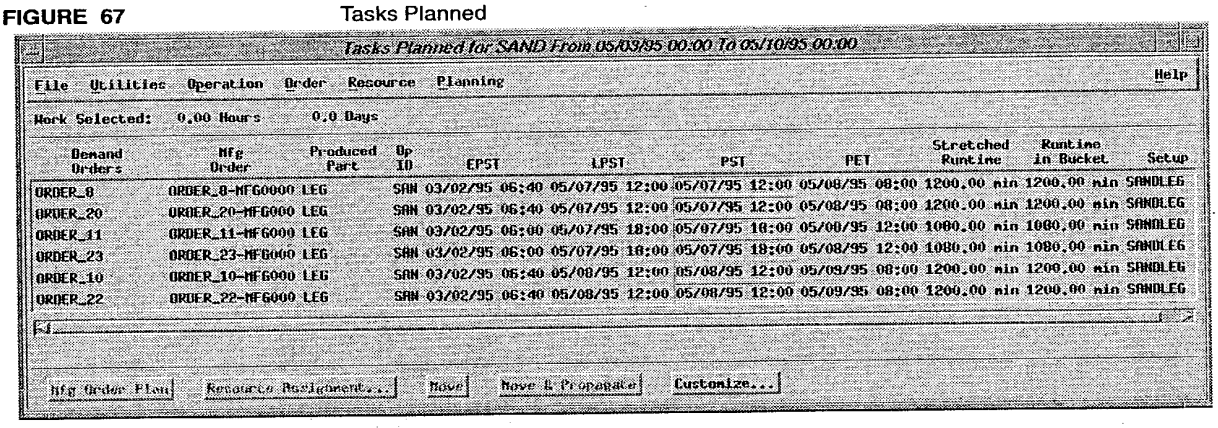


FIGURE 67 Tasks Planned



The *Tasks Planned* window (See FIGURE 67) displays information about the orders being worked upon this week. Three of the most interesting columns are labeled EPST (Earliest Possible Start Time), LPST (Latest Possible Start Time), and PST (Planned Start Time). EPST is determined by adding the cycle times of each step in the routings to the server start date while taking into consideration material constraints (infinite capacity, material-constrained, forward propagation). LPST is determined by infinite capacity, backward propagation from the due date. The PST is selected from within the time window delimited by EPST and LPST. If EPST is after LPST, the order will certainly be late and PST will be set equal to EPST.

From this window, we can:

- view the plan for a single order
- move work from one bucket to another bucket on the same resource
- off-load work to another resource
- automatically balance the work on this resource.

Now we will try to move work from an overloaded bucket to another bucket (preferably one that is earlier, so as to not make any additional orders late, but which is still after the operation's EPST).

Click the middle button on each order of interest in the *Tasks Planned* window (See FIGURE 68).	Selected orders should now be highlighted (selected). Note that the total amount of work selected is displayed at the top of the window.
In the *Tasks Planned* window, click on the *Move* button.	The *Move* button becomes highlighted. This will indicate that you want to move the load corresponding to the two selected orders out of the overloaded bucket.
Move the pointer to the bucket in the *Load Graph* (See FIGURE 69) where the load should be moved. If the *Load Graph* is not visible, reposition it so that it is visible.	Note that the pointer (when within the graph portion of the *Load Graph*) now has an icon which pictures the middle button.

Click the middle button inside the target bucket.

The load appears in the target bucket (See FIGURE 69). The *Tasks Planned* window becomes resized to accomodate a *Move Result* pane.

Look at the status message(s) near the bottom of the *Tasks Planned* window to verify you were successful (See FIGURE 70).

You have just manually replanned work for one overloaded bucket on one resource.

FIGURE 68 Tasks Planned - Selected

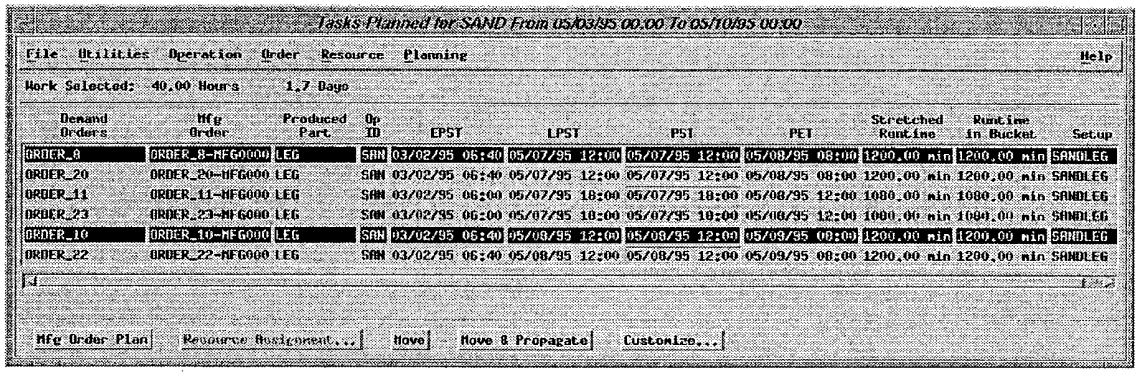


FIGURE 69 Load Graph - Moved Load

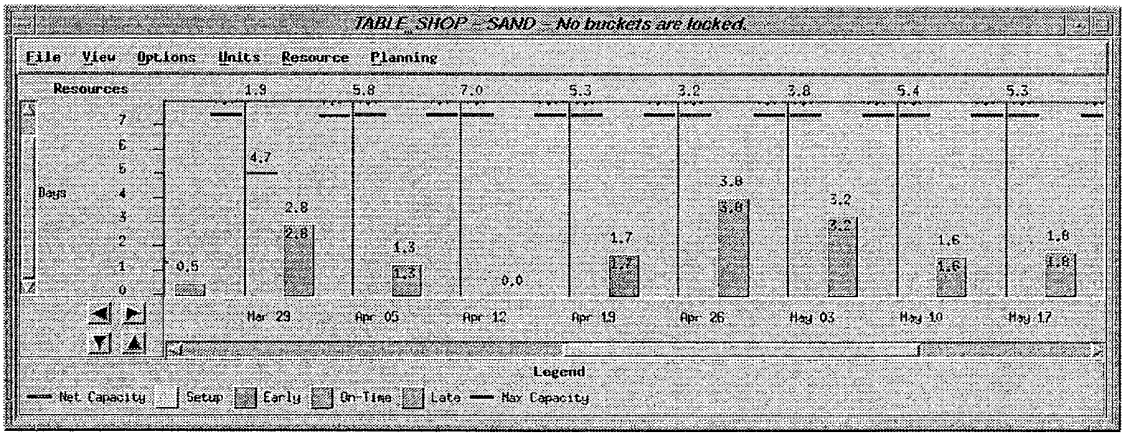
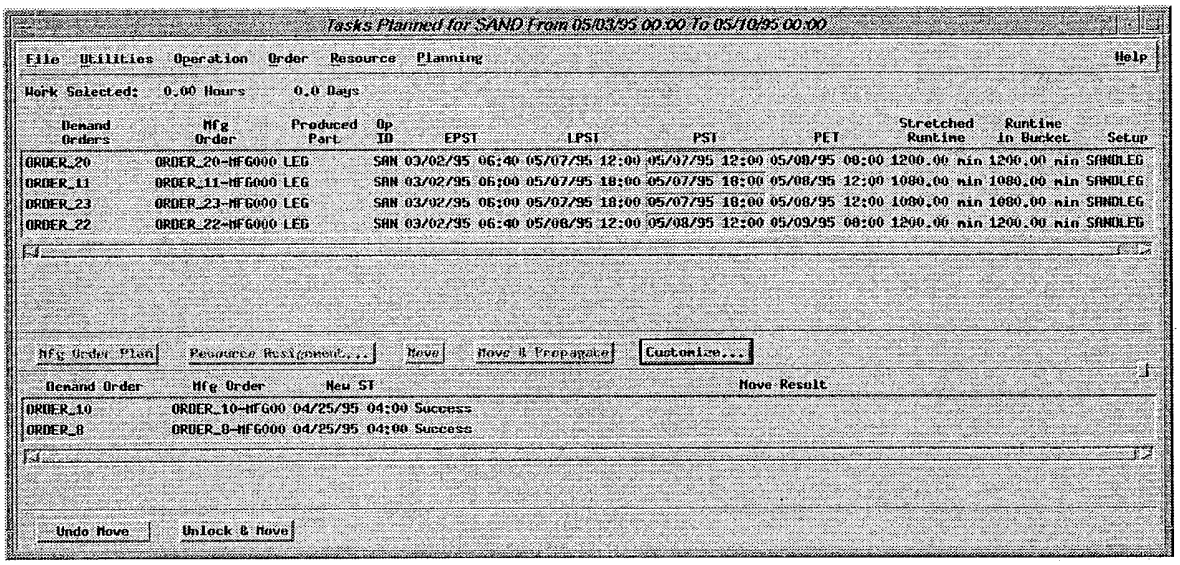


FIGURE 70 Tasks Planned - Moved



5.3 Lesson 20 - Alternate Resource

It is also possible to off-load work to another resource. To do so, you will basically follow the same steps as in the previous lesson, but push the *Resource Assignment* button rather than the *Move* button.

Let us try to move work from an overloaded bucket to another resource (same time bucket). The *Tasks Planned* window should still be open.

Click on an order in the *Tasks Planned* window that is to be moved.	The order will become highlighted (selected).
Click on the *Resource Assignment* button.	The *Resource Assignment* window will appear (See FIGURE 71). This window shows the current resource assignment and shows a list of alternate resources. The set of alternate resources is defined in *Rhythm*® data files for each operation. If no alternate resources exist, this is because they have not been defined.
If an alternate resource is listed, go to the *Main Window*, click on the resource (may be in a different *Location*) in the *Select Resource* list to select it, and click on the *Load Graph* button.	This will display a *Load Graph* for the alternate resource (See FIGURE 72).
Click on the alternate resource in the *Resource Assignment* window.	This resource will become highlighted (selected).
Click on the *OK* button in the *Resource Assignment* window.	*Rhythm*® will move the selected work to the same bucket on the alternate resource (See FIGURE 73). The *Resource Assignment* window will be closed. Compare the *Load Graph* for the current resource before (See FIGURE 69) and after (See FIGURE 74) the move of the selected work in a bucket to the alternate resource.

FIGURE 71 Resource Assignment

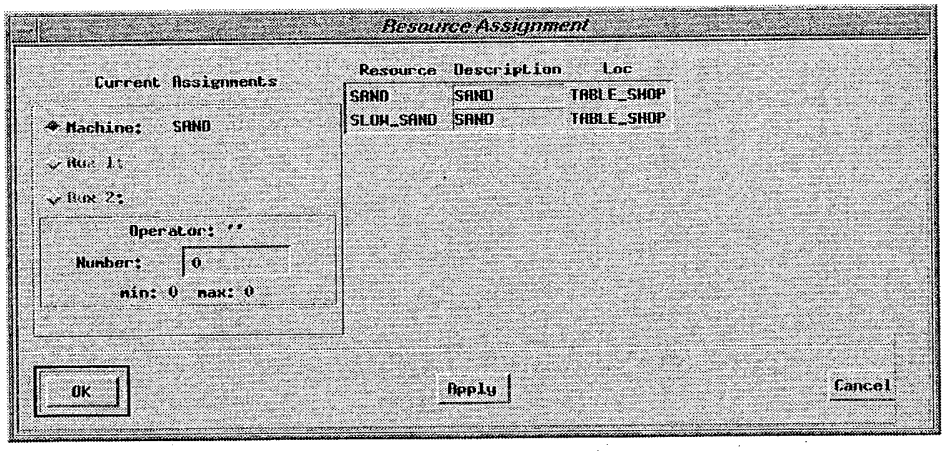


FIGURE 72 Load Graph - Alternate Resource

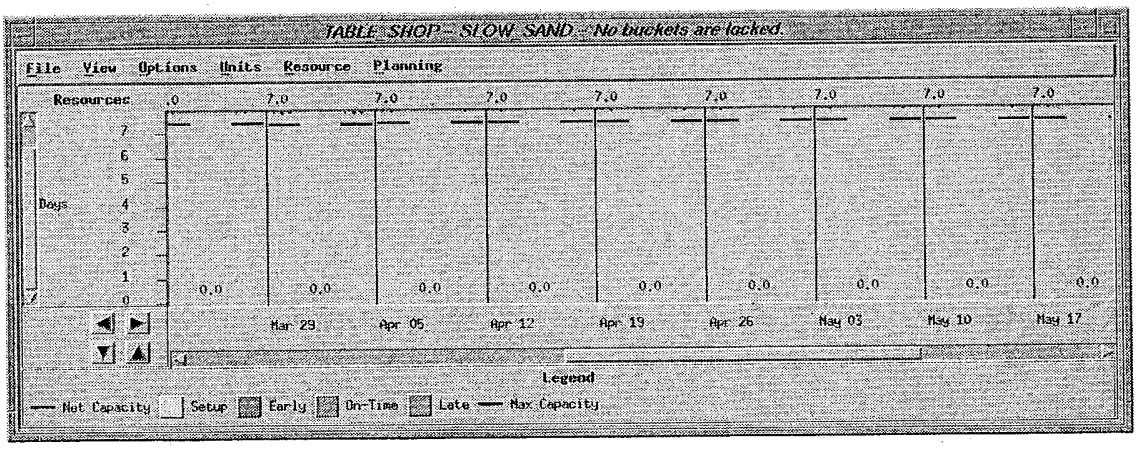


FIGURE 73 Load Graph - Alternate Resource After Move

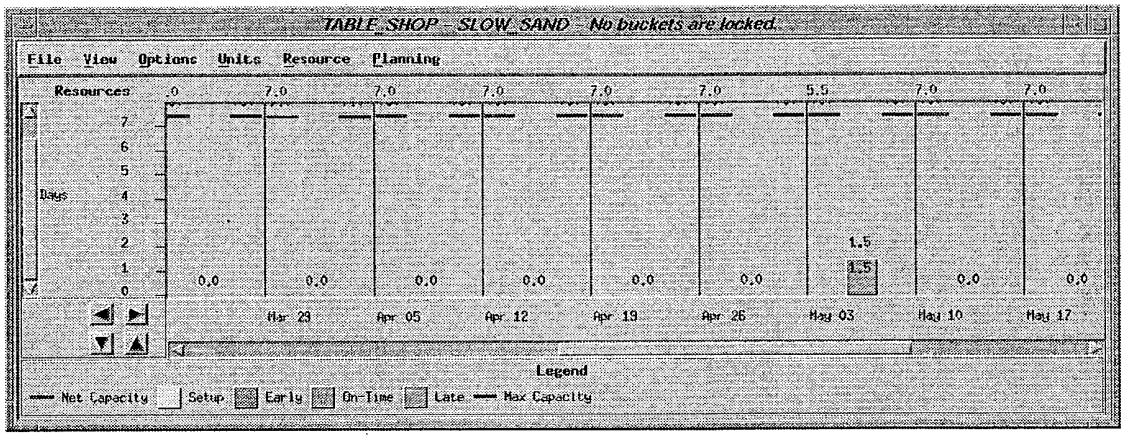
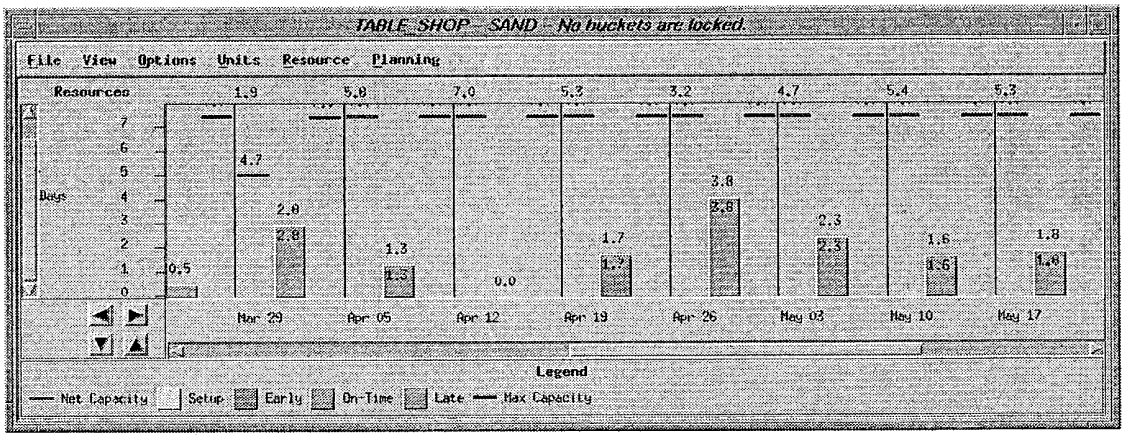


FIGURE 74 Load Graph - Current Resource After Move



Finally, it is possible to have *Rhythm*® balance the load for all time buckets on just this one resource.

Select *Balance* from the *Planning* menu on the *Load Graph*.

Note the changes in the *Load Graphs* for the resource (See FIGURE 75) and the alternate resource (See FIGURE 76).

FIGURE 75 Load Graph - Balanced

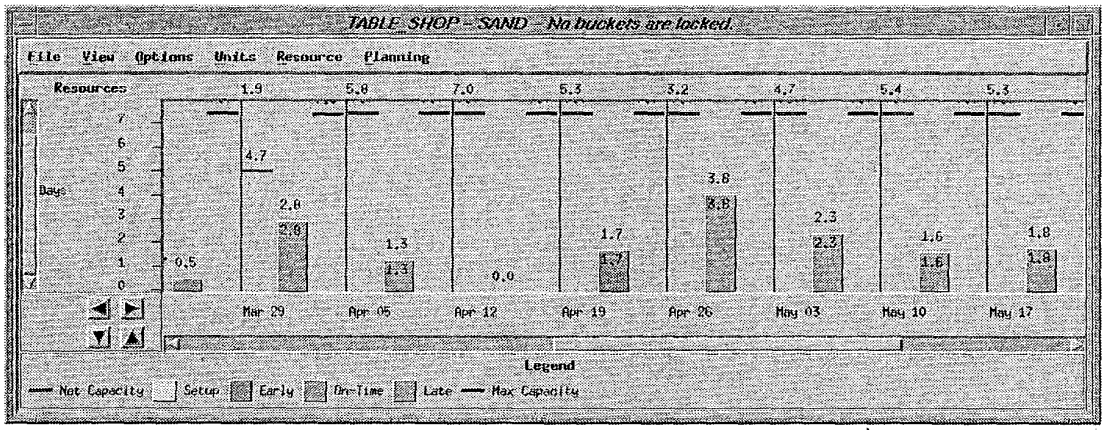
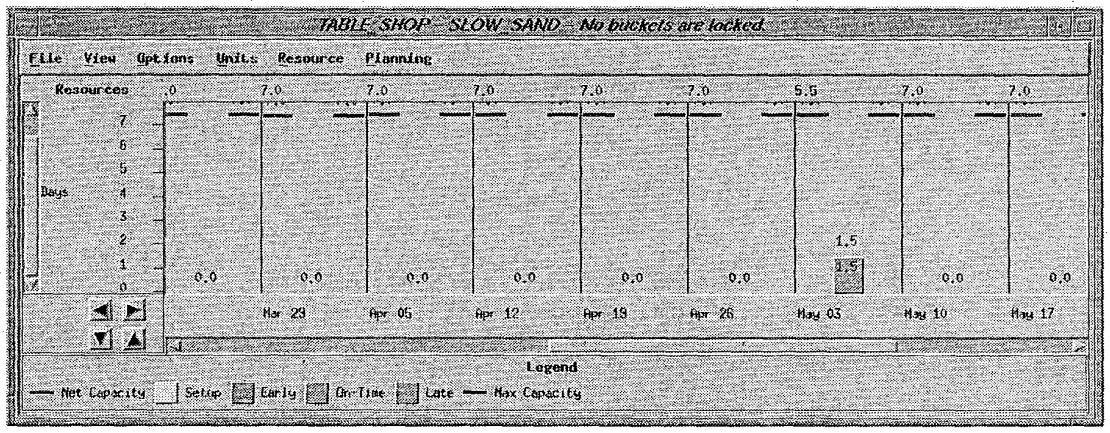


FIGURE 76 Load Graph - Alternate Resource Balanced



☞ A word of caution: balancing the load on a single resource may create capacity overloads at other resources. Later we will see how to balance the load on all resources simultaneously.

Close the *Load Graph* for the alternate resource.

Close the *Load Graph* window for the primary resource. Note that the *Tasks Planned* window also closes since it was opened from the *Load Graph* window.

In the *Problem Window*, click on the box next to *Capacity Shortages*. This will hide the list of *Capacity Shortages*.

5.4 Review

We have covered the following functionality in this section:

- Manually moved work in a resource *Load Graph* to different time buckets or alternate resources

Section 6 Starting Guide

This section introduces essential features of the operating environment where *Rhythm*® is used.

6.1 Training Objectives

After completing this section, you should:

- Have a general understanding of the client-server architecture
- Be able to start *Rhythm*®

6.2 Distributed Environment

Rhythm® is designed to function in a distributed computing environment that runs the UNIX operating system and X Windows. This section briefly introduces this environment. Contact your system administrator if you have further questions.

6.3 Client-Server Architecture

Rhythm® was designed using a client-server architecture. The server and client are two separate processes, both of which must be running to use *Rhythm*®. The server process is started first, and then client processes are started which communicate with the server process.

The server performs the majority of *Rhythm*® tasks. It:

- Builds the factory model from data files and ensures consistency
- Generates the plan, which includes material planning, forward and backward propagation to calculate EPSTs and LPSTs, allocation of inventory, determination of PSTs, and generation of the infinite capacity plan
- Maintains the plan as changes are made

The client may run on a different machine than the server, in which case it communicates with the server through the local area network. The client gives the user an interface to the current plan and data. Specifically, it allows the user to interact with the *Rhythm*® server (and the data set loaded by the server) via a graphical user interface (GUI) operating under X Windows using the Motif widget set.

The client-server architecture allows multiple clients to run simultaneously, which means that multiple *Rhythm*® users can be working with the same data set. The effect of changes made by one user will be visible to all users. Interactions can be avoided by running both the server and the client on a separate port, which will be covered later.

6.4 Lesson 21 - Starting Rhythm

6.4.1 X Windows

Make sure that X Windows is running.	If you do not have an xterm window with a command line prompt, contact your system administrator.

6.4.2 Server

The server process must be started before any client processes.

To start the server, at the prompt type the following on one line: *./rhythm_server -date 1/1/94 -dir ~/usr/local/rhythm/training -progress &*	The first part of this command is the name of the server, which can be renamed by your system administrator. It is followed by command line options, which begin with a dash. The first server option is *-date date*, which tells the server to generate a plan starting at that date (we specify this particular date because the tutorial data begins with this date--typically you would not need to specify the date, and today's date would be used by default). The second server option is *-dir directory_name*, which tells the server where the data is located. The third server option is *-progress*. This option is not necessary, but will give you an idea of what tasks the server performs when it starts. The final part of the command is an ampersand (&), which tells the UNIX operating system to run the server process in the background. This will allow you to continue typing commands in the current window while the server runs.

6.4.3 Client

The client process can only be started after the server process has been started. When the server process issues the message *Handling requests from UI clients* you may start the client.

To start the client, at the prompt type:

./rhythm_client &

Note that again we used an ampersand (&) to run the client process in the background. This is not strictly necessary, but it allows us to later use the current window to enter UNIX commands if that should be necessary.

When the client process starts, *Rhythm®*'s *Main Window* should appear.

Depending on how your system is setup, a window may appear on the screen in one of two forms. First, it may be automatically placed. Otherwise, an outline of the window may appear, and you must move the pointer to the desired location, and click the left mouse button to cause the content of the window to appear.

To move a window after it has been placed, click and hold on the title bar of the window and drag it to the desired location, then release the mouse button.

6.4.4 Multiple Servers

In general, only one server should be used for on-line scheduling of a plant. However, in some situations it might be desirable to run more than one concurrent server process. For example, one server might be used for on-line planning and scheduling, while another server might be used to perform what-if analysis.

To start the server, at the prompt type the following on one line:

./rhythm_server -port <port number> (other options) &

To start additional servers, specify a four digit port number using the port command line option.

To start a client, at the prompt type:

./rhythm_client -port <port number> &

Use the same port number as the one used to start the server to start clients.

Each server process loads the factory model into core memory, and each client views the model of its respective server. Thus, changes made to the plan in one server will not be seen by clients connected to other servers.

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